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Water Resources of the East St. Louis District

BY

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ASSISTED BY
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STATE GEOLOGICAL SURVEY,
UNIVERSITY OF ILLINOIS,
URBANA, March 1, 1907.

Governor C. S. Deneen, Chairman, and Members of the Geological Commission:

GENTLEMEN—I submit herewith a report upon the water resources of the East St. Louis district, prepared by Mr. Isaiah Bowman of Yale University, assisted by Mr. Chester A. Reeds. This report is one of the results of the coöperative studies of the water resources of the State now being carried on by the State Geological Survey, the State Water Survey, the Engineering Experiment Station, and the United States Geological Survey. Originally it was planned that this particular work should be undertaken jointly by the State Geological Survey and the United States Geological Survey. It was accordingly begun by Mr. Bowman as assistant hydrologist, acting under orders of Mr. M. L. Fuller, chief of the eastern section, Division of Hydrology. Later it was found better to treat the work as a portion of the general coöperative work on the waters of Illinois, and the direction of the work was accordingly transferred to the State Geological Survey. Dr. Edward Bartow, consulting chemist to the survey, and director of the State Water Survey, has furnished a large number of the analyses used in this report, and has read and criticised portions of the manuscript.

It is not generally appreciated to what an extent the plants which contribute to the industrial importance of St. Louis are located east of the Mississippi in Illinois. For reasons, partly natural and partly artificial, which Mr. Bowman indicates, a very large number of the most important industries are located on the great level plain which forms the larger part of the East St. Louis district. In any manufacturing community an adequate supply of water for municipal and industrial purpises is of first importance. The rapid growth of this particular area and the great variety of industries present has seemed to warrant this special study. In the report an attempt is made to throw such light as the hydrologist may on the general water problems of the district. The specific problems of each village and city and of the individual industries are not here considered. These necessarily demand more detailed study than an officer acting for the State can be expected to give. Further studies of the boiler waters of this and other areas in the State

are now under way as a portion of the general coöperative work already mentioned. Their results will probably be published in the bulletins of the Engineering Experiment Station and the State Water Survey.

In the prosecution of this investigation assistance has been received from many sources which are in the main acknowledged in the text. To those mentioned and to the many others who gave time and effort to the work I beg to express the thanks of the survey.

Very respectfully,

H. FOSTER BAIN,

Director.

WATER RESOURCES OF THE EAST ST. LOUIS DISTRICT.

By Isaiah Bowman, Assisted by Chester Albert Reeds.

INTRODUCTION.

By Isaiah Bowman.

Nature of hydrologic investigation. It seems necessary in this place to indicate briefiy the nature of hydrologic investigations and the importance in a study of water supply of physiographic and geologic data.

The point of first importance is the occurrence of potable water, whether in the form of springs, streams, lakes, artificial and natural ponds, wells, etc. The person desiring water wishes to know where he can find it and in what amount. He wishes to know the chemistry of the water, whether it is pure and safe; and, if it is desired for boiler purposes, whether it will scale a boiler or whether it must be treated with a compound before it can be so used. The best manner of obtaining the water must also be known, the style of well drilling rig best suited to the given depth and the geologic conditions of the region. Data as to cost are also desirable, but are most difficult to obtain.

If the water supply is from streams it will be necessary to study the regime of the streams in question, the rise and fall of the waters, the permanence of sites for water works and reservoirs, and the liability to embarrassment from overflow. On page 31 is begun a discussion of the Mississippi as a source of water supply, and some of the most interesting as well as most difficult of the water problems in this district are encountered in the attempt to secure, purify and deliver river water. If the supply is from ponds or lakes the protection of the watershed is of paramount interest, and of great interest also is the effect on the quality of the water of the rank vegetation sometimes found in ponds where the water is too stagnant to be kept free from grasses and weeds.

The importance of geologic and physiographic data in determination of water supply must be recognized. The occurrence, quanity and quality of underground water supplies depend primarily upon geologic conditions. The texture of the rock will determine in part the amount of the water, and the mineral composition of the rock will affect the quality of the supplies. Since the structural interpretations are sometimes dependent upon paleontologic data this branch of science is also serviceable at times. Facts of this kind have been used to good advant-

age in several places in this report. Physiographic studies are frequently of vital importance in this field, as the topography determines to such a large extent the head of the water and the extent of the catchment area. This is particularly true of shallow supplies where the form and ever-changing position of the water table reflect the surface features, including the drainage.

In the discussion and interpretation of data of the kind commonly considered in this report it should be constantly borne in mind that whatever other qualities they possess, such discussions or conclusions are based upon evidence with which there must always be associated a certain degree of error. This is inevitable. The physicist or chemist dealing with precise measurements and accurately determined conditions may state with assurance the result of experiment or calculation. Likewise the field geologist in mapping outcrops and sketching sections deals directly with his subject; acquires information first hand. The hydrologist, on the other hand, acquires much of his information through a class of men, oftentimes unscientific, and these, standing between the fact and its interpreter, lend a certain inaccuracy to a statement of fact in a report. This is by no means usually intentional or even conscious, but the natural consequence of defective memory often slightly rèinforced by preference for a familiar interpretation.

Thus a well driller or well owner without a written record of a well section gives from memory an approximate section, and both the succession of beds constituting the section and the depths at which they occur may vary somewhat from the fact. Further than this, there is no possible way to determine the precise depths of formations in a bore hole other than by cleaning out the hole thoroughly and getting a sample from the bottom. In ordinary drilling this is not practiced and the drillings from one formation are mixed with the next lower one. It will be observed that for the usual purposes of the hydrologist no such refined measurements as the above criticism implies are necessary, but errors arising from lapses in memory are oftentimes serious. There is also considerable variations among drillers in the use of such words as sand rock, shale, lime rock, etc. Where records are supplied from memory they must be carefully checked, both as to depths and rock quality, by more trustworthy records.

The point of the whole matter is the necessity for a conservative estimate of the worth of each contributor's testimony and for diligent inquiry for reliable and conclusive evidence in which there is the minimum of error. It is this point of view that the author has steadfastly maintained in the collection of the facts set forth in the following pages. Many of the conclusions are based on direct evidence; those based on less reliable evidence are stated in conservative form. It is hoped that this method will prevent error in the practical application of the results.

Location and extent of the East St. Louis district. The East St. Louis district of Illinois, as the term is used in this report, includes the city of East St. Louis and that part of the surrounding territory that lies within what is known locally as the terminal limit, or the yard limits of the Terminal Railroad Association. As thus defined the dis-

trict is limited on the west by the Mississippi river and on the east by the towns, Belleville and Edwardsville. Among the larger towns lying within the area may be mentioned Alton, Granite City, Madison, Collinsville, O'Fallon and East Carondelet. The boundaries of the district do not conform to county or town boundaries, but follow an irregular course.

Manufacturing interests. In this district there has been a rapid growth in manufactures in recent years and a corresponding growth of interest in the problems of water supply. Today the problem which confronts the manufacturer is of most serious proportions, and everywhere the writers found the keenest interest in the activities of the State Survey in this direction, and an earnest desire to assist the work in every possible manner.

Acknowledgements. It is, therefore, with great pleasure that acknowledgment is here made of assistance given by well owners in this vicinity. Competition in industrial life is of such a character that any data obtained from experiments are carefully guarded by the experimenter, and a rival company is obliged to go to the expense and trouble of repeating the experiment if it desires the information. The East St. Louis district offers many examples of this kind in connection with the development of untried sources of water supply. It was with unusual satisfaction that these men saw the problem undertaken by the State Survey, and information which had been jealously guarded for years was cordially placed at our disposal. It was recognized that our recommendations would be valuable in strict proportion to the completeness with which the data were gathered. The State is an impartial collector and adviser, and in a problem of such vital and practical interest can offer a reasonable solution only when all the witnesses in the case are impartial and helpful. Acknowledgement is made on different pages of special assistance, the complete list being too long to include here.

It is desired especially to acknowledge the coöperation of the U. S. Geological Survey in this work. As originally planned the study was to be conducted by both the State and the national surveys, the results to be published in a water supply and irrigation paper. The funds available for hydrographic work by the U. S. Geological Survey were not sufficient to allow further coöperation with the State Geological Survey of Illinois, and on June 20th, 1906, the former arrangement was terminated, the U. S. Geological Survey, acting through Mr. M. L. Fuller, chief of the eastern section of the Division of Hydrology, generously placing all data acquired up to that date in the hands of the State. No change was made in the personnel of the field party in charge of Mr. Bowman, the work being continued uniformly until July 25th.

Plan of report. Attention is called to the two-fold character of this report. In the first place it deals with the present hydrographic conditions in the district, each source of water supply being described in details as to quality, amount, availability, etc., and in the second place, it makes certain recommendations based on the facts in the case and the lessons of former experience in water problems. It is believed

that the former will be of practical interest in the actual tapping of a given source; and it is believed that the latter will be useful to any well owner who finds himself confronted by any one of the several difficult situations noted in the following pages.

ECONOMIC FEATURES.

(By Isiah Bowman.)

East St. Louis as a manufacturing site. Many physical conditions lead to the embarrassment of the East St. Louis manufacturer. Foundation sites are always poor, the grounds and buildings are often inundated at high water, and the securing of an adequate and cheap supply of water is oftentimes rendered exceedingly difficult. The layman is, therefore, led to inquire why the site is not abandoned and manufacturing plants located nearer the center of the city and the homes of the workmen. The answer to this query is found in an economic situation, unique in that it transcends every other condition, physical or political, in this section of the country.

Determination of sites. To understand the situation it is necessary to turn to a problem in transportation, and if this does not seem to be germane to the question of water supply, it is only necessary to recall that manufacturing sites are located in given places, usually not for one but for several reasons among which there may be a certain incompatibility requiring adjustment. If a sufficient number of conditions are favorable a site is selected accordingly, the manufacturer seeking to amend the less favorable conditions to the point of toleration. One cannot in the present instance adequately understand the seriousness of the water problems without recognizing how serious are the conditions which demand that the sites for these great plants shall be located on the east and not the west side of the Mississippi.

Basic points in railroad transportation. In the organization of any railway system the problem of freight charges is commonly solved by referring the shipments to what are known as basic points. That is to say, suppose a railroad runs from Minneapolis to New York and passes through Chicago and Pittsburg. These four cities might then become basic points, with the result that three separate shipments of flour from Minneapolis to each of the other three cities would be charged separate rates, and these rates and not proportionate rates would be charged on all freight to intermediate points. Consequently the cost of a shipment of flour to any point east of Chicago and west of Pittsburg would equal the cost of shipments to the latter city, although the distance might be several hundred miles shorter. Railroad men contend that the enormous expenses attendant on the purchase of land in the large cities and the erection of terminal stations, freight sheds, main tracks, switches, etc., must be paid for either by the excess noted above or by the introduction of considerably higher rates over their entire lines. The former is certainly the easier way from the standpoint of the railroad; and as the largest shipments and

therefore the keenest competition occurs between the large cities, it is clear that the latter expedient would involve the management in one of the gravest difficulties of transportation. It is not our purpose to discuss this question from either the legal or the equitable standpoint; we shall merely describe the practice and its application to the district under consideration.

In the early development of the railway system in the St. Louis district East St. Louis and not St. Louis was made the basic point for shipments and has remained the reference point up to the present. In making shipments to St. Louis from eastern points a certain rate is charged to East St. Louis, and transhipment to St. Louis involves the shipper in the same expense he would incur by shipment to the next western basic point.

Bridge Monoply. The above condition is coupled in the minds of residents of this district with the alleged fact that the St. Louis and East St. Louis terminals are managed by a monopoly or combination of the thirteen or more leading railroads which enter the city. As these railroads under the name of the Terminal Railroad Association of St. Louis own and control the Eads bridge and are being asked by the U. S. Government to disprove ownership of the Merchant's bridge, and further, as these are the only two bridges across the Mississippi river at this point, it will be seen that the conditions seem to operate to a certain extent to restrain trade from crossing the river.

Public opinion in regard to the situation has been adverse to the railroads, and the St. Louis representatives in Congress secured the passage in June, 1905, of the Hunt bill, which authorizes the city of St. Louis to construct a so-called free bridge across the Mississippi, which can be used without the payment of a toll, as at present, or the payment of an additional fare on street cars.

Transportation rates across the Mississippi. The actual working of the transportation system as at present organized means that every loaded car crossing either the Ead or the Merchants' bridge into St. Louis pays a toll of $5.00, for every ton of coal burned in St. Louis costs the user 30 cents more than on the east side of the river, this amount being the toll on every ton of coal passing over the bridges. The word "toll" as used above is the designation of the citizens of this city; the railroad people call it freight—the ordinary cost of shipment beyond a basic point.

Coming still closer to the problem of the manufacturer it is seen that where, as in one instance, 400 to 450 tons of coal are consumed daily by a single manufacturing firm, the extra cost per day, were the plant located in St. Louis, would be $120.00 or more, or an excess of $30,000 per annum on coal alone. The iron and steel works get their raw materials from the eastern side of the river, and coal is mined almost within sight of these works. Furthermore, a part of the manufactured product, sometimes the larger part, is marketed in the eastern or middle states. and a location in St. Louis would mean the payment of large sums on both the raw and the refined products. Even when, as in one or two instances, the greater part of the manufactured product is shipped to western points, the saving on the

difference in weight of the crude and the refined product, plus the saving on coal, tends to keep the manufacturer on the east side of the river.

Land values and business facilities. Manufacturing interests assert that it is this condition relative to transportation that has resulted in their centralization at East St. Louis. The lower cost of land on the more thinly populated flood-plain of the Mississippi has been a favorable but not a determining condition. Location near a great city has resulted in the easy acquisition of ordinary business facilities—the telephone, telegraph, newspapers, etc. Through the enterprise of manufacturers and other citizens, well built towns have grown up rapidly, so that, for the most part, workmen live near their work.

As previously pointed out, the site is not ideal, involving as it does, damage from flood and insecure foundations. It is not, therefore, ordinary business growth that is exemplified in East St. Louis. It is distinctly a growth dependent on a combination of economic and physical conditions, operating in such a manner as to make the Mississippi a barrier to manufacturing interests, holding them on the east side, which, economically considered, is the better, but, physically considered, is decidedly the poorer.

Finding himself in this location, the manufacturer turns to the less favorable conditions and seeks to ameliorate them. One of the first of these is that of water supply, to which this report is devoted.

The hydrographic features of the region will be more readily understood from a brief study of the physiographic and geologic features.

The manufacturer is not the only one to whom the subject of water supply is of interest. Towns and villages, oftentimes quarrymen, farmers and bottling concerns are affected by water conditions, and some of our recommendations may be of service to municipal authorities seeking to improve either the amount or quality of municipal supplies.

TOPOGRAPHIC FEATURES.

(BY ISAIAH BOWMAN.)

Topographic subdivisions. The control which topographic features exercise over the disposition of both surface and ground water is often immediate and dominating. In the East St. Louis district the influence of topography is emphasized by the sharp topographic contrasts displayed between the eastern and the western sections of the area. That part of the district which adjoins the Mississippi river and which lies at an altitude above mean sea level of about 400-420 feet, is known as the flood plain of the Mississippi and is referred to in the reports and on maps of the Mississippi River Commisson as a part of the "Upper Alluvial Valley of the Mississippi." The eastern part of our district will be referred to as the upland portion in contrast to the lowland portion or the flood plain. The boundary between the two portions is constituted by what are known as the upland bluffs—the westward-facing escarpment which runs irregularly across the area, roughly from north to south, as shown in Plate 4.

THE MISSISSIPPI FLOOD PLAIN.

Origin and development. The topographic and drainage features of the lowland portion of this district may be best described in terms of the origin or genesis of the flood plain. Any meandering stream is at once a constructive and a destructive agent. In swinging from side to side the current of the stream increases the size of the curves and these impinging on the valley sides increase the width of the valley. As a consequence the valley grows constantly, and the marks by which such growth is attained are often very clearly shown in the form of sharp notches in the upland bluff, as viewed in plan, the notches representing meander embayments exactly similar in mode of origin to meander embayments now actively occupied by the river. Such notches may be seen one mile southwest of French Village, one mile south of Centerville and one miles north of Imbs. The last named one is the largest and produces a jog of several miles in the upland bluffs between Stolle and Centerville. In the East St. Louis district the Mississippi is nowhere, except at Alton, actively working on the upland bluffs of Ilinois, its activities in this direction being confined almost exclusively to the western bluffs above and below St. Louis.

The broader outlines of the upland bluffs which limit the flood plain on the east, and which play so important a role in the acquisition of water in this region, are therefore to be considered as a function of river action plus the resistance of the rock to stream erosion. As will be shown in later paragraphs, the details of form exhibited by this bluff enter very significantly into certain problems of water supply. These details may be understood from the fact that other agents than the river are at work to modify the outlines of the escarpment. The wash of the rains, the tiny streams which drain the edge of the upland, changes in temperature, the roots of grasses and trees, all combined with that insistent force called gravity tend to the reduction of such steep forms as a river-cut bluff. No sooner then has the river ceased to trim and steepen the sides of its valley, than the sharp outlines of the bluff become fainter, more rapidly where the material is friable, as sand, gravel or loess, less rapidly where it is hard, as compact sandstone or limestone, etc. Thus from Alton southeastward and southward as far as Prairie du Pont the upland bluff has been well dissected because the material slumps down quickly, tons of the loess and sand and clay being transported toward the flood plain during every rain storm. The effect of this dissection is seen further in the alternation of the sprawling spurs and the huge alluvial fans which terminate the upland valleys along the line of the bluff. Since the river has withdrawn itself from the eastern bluffs to its present position, the tributaries on this side have all been lengthened accordingly. The abrupt change in grade from the steepened upland portion to the almost flat lowland portion has resulted in the deposition of the long and flat alluvial fans which the streams overflow in high water during the wet season or after heavy rains in any season; or dissect during low water, the streams in some cases running in narrow and deep trenches through the fans they themselves have built. A corresponding diversity in the occurrence and amount of ground supplies is noted on later pages.

In places where harder rock constitutes the bluff its form as a product of river trimming has suffered slight changes since abandonment by the river. From Stolle south to the limit of the district a line of almost vertical bluffs exhibit, as shown in Plate 4, a sharp contrast to the part just described. A talus from 30 to 50 feet in height borders the foot of the bluff, but above this the bluff is sheer with outcropping ledges of limestone capped by a sheet of loess varying in thickness from several inches to 15 or 20 feet. At intervals where tiny catchment areas occur in the upland back of the bluff, hills have cut true gorges in the loess, which frequently erodes with vertical face. In the development of curves in a river with an irregular course, the radius of curvature in a given instance decreases steadily as the curve becomes sharper, until a point is reached where a true meander is developed, and from then on any further change is marked by an increase in the radius of curvature * until a cut-off occurs and the meander is abandoned by the river. The process of meander development as described has the further accompaniment of a bodily movement of the curve down stream. In this way the meander exercises a planing action when it is developed in contact with a bluff and trims off the bluff continuously until a cut-off intervenes. It is this feature of planing by downstream movement of the meander, as well as the lateral increase of the meander, that give such notches as occur north of Stolle, and elsewhere, their distinctive character.

The material disloged by the outward and downward development of the meander is in part carried to the sea and in part temporarily redeposited on the flood plain. This process of excavation and redeposition is known as "cut and fill," and to its present activity in this section may be ascribed one of the most serious difficulties encountered in the attempt to utilize river water.

It follows from the behavior of a river that no flood plain will be perfectly smooth, but that there will be slight irregularities in cuts and fills due to the varying regime of the river. Here and there will occur bayous or cut-off lakes whose outlines, although partly modified since formation, will still reflect the curve of the meander of which they were once a part. Inborne sediments will accumulate, the bayou will be partially silted up and marshy tracts with curved outlines may take the place of standing water. The minor irregularities of the flood plain are very clearly exhibited in many of the maps published by the Mississippi River Commission. (See sheets Nos. 115, 116, 117,, detail map of the upper Mississippi river. Scale, 1 :20,000. Contour interval 3 ft.) The larger features of the bluff and bayou appear in Plate 4. The irregular action of the river are treated in the discussion of the geological features of the district.

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*Isaiah Bowman, Deflection of the Mississippi, Science, N. S., Vol. XX, No. 504, August 26 1904; pp. 273-277.

†Chamberlin and Salisbury, Geology, Vol I. 1904; p. 183.

UPLAND DISTRICT.

Characteristic features. That part of the upland included in the East St. Louis district lies so near the lowland bordering the Mississippi that it is much more fully dissected and therefore uneven than more central portions of the State. The process of dissection has, however, not been carried to the point of maturity—that is to the point where the maximum of slope has been produced—as is shown by the flat and still undissected patches of upland which occur two miles south of Caseyville, one mile northeast of Belleville, and in the vicinity of 'O'Fallon and elsewhere. The last named example well illustrates the encroachment on still undissected portions of the upland of active and steep-sided ravines tributary to the larger drainage lines. The quality of steepness in minor slopes is quite commonly emphasized in this district by the weathering habit of the loess; and to this quality may be attributed the conservation of a larger portion of the rainfall as ground water than where the material consists of ordinary loose sand and gravel. For while the run-off is more rapid on the steeper slope, this effect is more than counteracted by the larger proportion of level land, both on the undissected portions and in the flat bottomed valleys. As a consequence successful wells may be located nearer the edge of the ravine bluffs and the streams than otherwise.

General effect on ground water. This may appear more clearly from the consideration that the surface of the ground water or the water table, follows the trend and direction of the surface drainage; that the slope of the water table is essentially similar to the slope of the surface of the ground, differing from the latter principally in being less steep.

The similarity of the contours of the water table to those of the land surface enables one to sketch approximately the lines of underground seepage from a contour map of the surface.

No fact points more clearly than this to the necessity of a thorough understanding of topographic conditions in arriving at an understanding of the occurrence, movement, etc., of ground water supplies.

Valley development on margin in relation to reservoir sites. A feature of slope arrangement in the East St. Louis district which lends considerable interest to this view of the case is displayed along the upland bluff. In the process of valley widening as dependent upon the development of the meanders of the Mississippi, many minor tributaries were gradually shortened in an up-stream direction until at last the stream was in some cases betrunked, and the little individual headwater tributaries are now almost, if not quite, isolated. Such a case is exhibited east of Centerville at the point where the Illinois Central R. R. ascends the upland bluff. The same feature is recognized at Caseyville and above Alton Junction.

In such cases the grades of these headwater sections are of course steepened to correspond to the lower level enforced by the master stream. This is accomplished by the excavation of large amounts of

*Chas S. Slichter. "The Motions of Underground Waters." Water Supply and Irr. Paper No. 67. U. S. Geol. Surv., 1902; p. 32.

†Ibid, p. 33.

material near the point where the tributary debouches on the floodplain; such material being in part accumulated in the form of an alluvial fan stretching forward from the bluff. To the eye of the engineer the mouth of the deepened tributary, with its converging drainage lines, offers a most desirable focus for a dam site and reservoir (as shown in Fig. A, Plate 2.), and if the water shed can be adequately protected from impurities and no legal difficulties are interposed by residents, these localities, or similar ones, are frequently chosen. The advantages of such a location include easy delivery of the water to towns on the floodplain at much lower elevation and a head great enough to guarantee one of the most vital elements in fire protection. It is not believed that this resource is generally appreciated, and inasmuch as conditions identical to the above are exhibited in many sections of the State (As along the Illinois river for example. See the topographic sheets, U. S. Geol. Survey, Desplaines, Dunlap, Hennepin and Lacon) it seems desirable to emphasize it at this point.

Further consequences of the quick descent of the upland to the lowland and the pattern of the drainage are discussed on later pages. The matter assumes a high value in this district because wagon roads and railroads seek the drainage lines as the easiest means of descent to the floodplain, and this confluence of routes at the debouchure of the principal valleys has determined the sites of many villages just under the bluff. Peters, Caseyville and French Village may be cited as examples. Whenever population is concentrated, even if only to a limited extent, as in the small towns named, problems of sewage disposal and water supply have at once a more or less vital interest.

FEATURES OF THE KARST.

Sink holes and caves. A section of the upland which is of more special interest than any other part lies on the southern margin of the district and includes the area between the upland bluff south of Stolle and the westermost tributary of Hickman's creek, in turn a tributary of Prairie du Pont. The St. Louis limestone appears here at a higher level than further south, and has been extensively dissolved out by the action of ground water. This action, for limestone regions in general, and the evolution of the topographic forms to which it gives rise, have been well described by Penck.* The phrase "karst topography" is commonly used to designate it, following the usage in the Adriatic provinces of Austria, where the feature is well developed—the name being derived from the Karst mountains of that vicinity.

The most striking characteristics of the district are the entire absence of trunk drainage at the surface, and the extensive development of sink holes.. The general appearance of the surface is shown in Fig. B, Plate 1. Rainfall is concentrated in tiny channels which converge toward the center of the sink where the waters escape through cracks

*Albrecht Penck. Uber das Kartsphänomen. Vorträge des Vereines zur Verbreitung naturwissenschaftlicher Kenntnisse in Wein XLIV, Jahrgang, Heft 1, 1903.

A. Impounded headwater drainage showing dam and reservoir one and one-half miles south of Sparta.

B. General view of Karst topography four miles south of Stolle, showing numerous sink holes and absence of trunk drainage at the surface.

and funnels in the limestone below. Occasionally the limstone outcrops on the side of the sink, but for the most part the sides are composed of the loess which overlies the rock, and slopes with an even grade down to the exits. If the same rate of escape of the accumulated water exceeds the rate of supply, the bottom of the sink is small, indeed the sink may be without bottom, sloping gradually down to the funnel continuation; but if the rate of supply exceeds the rate of escape, the water accumulates at the bottom and forms a pond. The surface independence of adjoining sink holes and the absence of integration of slopes is quite common and is shown by the considerable difference of level in two adjacent sink holes, oftentimes as much as 20 feet in a lateral distance of 100 to 200 feet.

The combination or the two outlet features noted above with that of difference of level is sometimes taken advantage of by the farmer in draining a sink hole and rendering it cultivable. Plate 2 shows two sink holes, the one in the foreground being lower and having a good outlet. The outlet of the one in the middle distance has become choked and standing water results. By constructing a short, deep trench through the common rim of the two, the upper one is drained into the lower and the feature of standing water is eliminated. Frequently the slopes are too steep to be cultivable, and in such cases no effort is made to drain the sink, and trees and bushes are allowed to cover the sides and bottom, giving the landscape a peculiarly mottled and patchy appearance.

An occurrence of stoppage in a sink funnel, of unusual interest and suggestiveness in this connection, took place recently in the Karst district of Florida, near the city of Orlando. About two years ago the subterranean outlet of a sink hole became stopped. More than a dozen neighboring lakes had discharged into the sink hole, and their pent-up waters now overflowed, forming a great lake which eventually covered 250 acres of the surrounding lower land, driving many people from their homes and covering gardens and cultivated fields. The manner in which the outlet passage became clogged is a matter of conjecture. It may have been from a cave-in of the walls or from an accumulation of water hyacinths which formerly filled the sink. Many attempts were made to open the passage—by dragging the bottom of the sink, exploding dynamite among the collected debris, etc., but without relief. At last the idea occurred of making a new opening by the construction of a well. A two inch hole was first drilled, down which the water escaped easily and rapidly; then an eight-inch hole was drilled, and from these two all the accumulated water eventually escaped.*

Combinations of normal and Karst topography. The most peculiar topography which occurs in the entire East St. Louis district, is found on the borders of the sink hole area where the Karst topography grades into the normal. It can be understood by recalling the characteristic features of both classes, and the fact that now the one, now the other tendency will dominate. The resultant, expressing as it does two tendencies in varying relation will then not be difficult of analysis. Where surface drainage is maintained because of a weakening in the

*The Scientific American, quoted by the Literary Digest, vol. 33, No. 5, Aug. 4, 1906: pp. 147-148.

tendency toward the formation of sinks, the stream valleys have an abnormal profile. The valley sides steepen continuously to a maximum at the valley bottom instead of having the smooth outline of the reversed curve. The general appearance of such a valley strongly suggests the idea that the valley bottom has sunk somewhat, in readjustment to the changes taking place in the dissolving limestone, but that the sinking has not been sufficiently rapid to break up the continuity of the surface drainage. Examples of this feature may be seen in several places, particularly about one mile north of Wartburg beyond the southern margin of the map, Plate 4. In some cases the two tendencies are more evenly balanced, and while the country is distinctly broken up into sinks in response to sub-surface changes. the sinks drain into each other, the lip of each higher one being cut slightly by water spilling over into the next lower one. There is thus established a certain interdependence between neighboring sinks in spite of the strong expression of the Karst.

The combination of normal and Karst topography is sometimes expressed in the form shown in Plate 2. A stream valley or ordinary appearance may be formed in sandstone or in limestone not subject to the dissolving action of water. But if its course is toward a limestone district in which the sink feature is developed the valley may terminate sharply in a sink. Figure 1 shows a case several miles south of Burksville Station, Ill. The four openings by which the water escaped to underground passages are shown in the sketch. These openings are from one to two and a half feet across and are about seven feet below the floodplain. One feature of the openings shown in the figure is of especial interest. They do not lead vertically downard, but, developed along the joint and bedding planes, drop by short steps to lower and lower levels until the level of the ground water is reached, when the inflowing water partakes of the general lateral movement of the ground water in underground passages in the limestone.

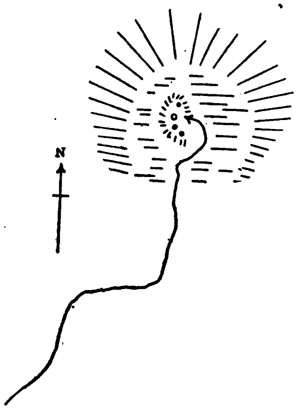

FIG. 1 Expressing combination of Karst and normal topography two miles south of Burksville station. The stream runs on a small tract of Chester sandstone and disappears in a sink-hole as soon as it reaches the karsted St. Louis limestone.

Perhaps nowhere else in Illinois are the surface drainage and water conditions so peculiar as in this section, and certain recommendations on pages 54-55 can be understood only if the special nature of the conditions are kept in the foreground.

Artificial drainage of higher obstructed sink-hole into lower, having good underground connection. One mile east of Falling Springs.

HYDROGRAPHIC FEATURES.

(BY CHESTER A. REEDS.)

(Compiled from various sources, chiefly from the paper by Helm, noted below.)

GENERAL.

Streams in arid and humid climates compared. As any accurate map of the truly arid sections of the west will show, the streams in desert climates do not run to the sea in surface channels. And if the ground water of such a region reaches the sea it is by seepage far below the surface. In such cases the streams end abruptly in long waste fans slopes built of loose and highly porous materials. On the other hand, regions such as the one in which the East St. Louis district lies are generally thought to be of quite different habit, *i. e.* as reaching some master stream, like the Mississippi, by means of well-defined channels on the surface.

It is therefore with some surprise that one views the drainage relations of the streams tributary to the Mississippi river in this district, and sees that in some respects the streams of the region imitate those of an arid section. This fact and its fundamental relation to the water resources of a floodplain, together with other facts, are of the greatest importance, and the details of the drainage problem, therefore, will be first considered.

Classification of drainage system. Following Helm's* classification, the hydrographic features of the upland and the floodplain of the Mississippi will be decribed under the Wood river, Cahokia and Priaries du Pont drainage systems. In addition to these three drainage systems there is the Mississippi itself as well as two creeks in the southern part of the district known as Silver creek and Richland creek, both tributaries of the Kaskaskia.

DESCRIPTION OF DRAINAGE SYSTEMS.

WOOD RIVER.

This system drains the extreme northern portion of the district. It is formed by the confluence of two branches, the East and West Fork, which unite to form Wood river, at the western margin of the upland, then flow southward about three miles to the Mississippi river. The two forks have their sources in the southern part of Macoupin county, about sixteen miles above its mouth. The stream has a drainage area in the upland of approximately 117 square miles and in the floodplain of 3 square miles, and has a maximum discharge of about 2,900 cubic feet per second.

Upland section. The datum plane used in the following descriptions will be the low water mark or zero of the Mississippi river guage in the city of St. Louis, and all elevations given are in accordance with that datum. The streams in the upland have comparatively steep gradients, being 200 to 250 feet above the level floodplain of the Mississippi.

*E. G. Helm, "The Levee and Drainage Problems of the American Bottoms." Jour. Assoc. Eng. Soc., Vol. XXXV, No 3. September, 1905, pp. 99-116.

They derive their water from the ground water and from rainfall. In the rainy seasons the floods gash the slopes, tearing away many cubic feet of earth.

When these immense volumes of water reach the level floodplain their velocity is checked, for here the same streams have no steep gradients or broad channels to carry off the surplus. As a consequence, much of the sediment in these streams is deposited in delta or fanlike forms at the foot of the bluffs, and the water gradually inundates the surrounding country.

Flood-plain section. That part of the channel of Wood river which lies in the flood-plain is entirely west of the Big Four railroad, and in freshets its flood waters are here confined. On June 29, 1902, the water from this stream was six to eight feet deep in the streets of East Alton, having washed out the tracks of the Big Four railroad, and overflowed that part of the flood-plain just to the east as far south as Edwardsville Crossing, where it was stopped by the embankments of the Illinois Terminal railway (except what passed through a 12-inch or 15-inch pipe). This happened a few times before, but with less extreme height. Generally speaking, Wood river may be considered as having no effect on the flood-plain, except on that portion contained in its own drainage area west of the Big Four, about three miles of territory. The water in the lower course of the stream is always muddy. Through the first mile after entering the flood-plain it flows over a limestone bottom which holds up the grade nearly ten feet higher than that of other streams having earth bottoms. When the rock bottom is passed, however, the water rapidly falls the distance of ten feet and enters the Mississippi river at the level of low-water mark at that point. Thus, since the waters of this stream are not checked by a low gradient and a long tortous course across the flood-plain, they run off readily and are not so troublesome as the other streams.

CAHOKIA CREEK.

Upland section. The Cahokia creek system drains over half the area of the flood-plain, or, as has been said, all that portion north of the Vandalia railroad and east of the Big Four railroad. The stream has its source in the vicinity of Litchfield, Montgomery county, flows in a general southwesterly direction, entering the flood-plain about twelve miles north of the south line of Madison county, nearly 35 miles south of its source. On the upland it drains an area of 228 square miles; at the point of entering the bottoms it is joined by Indian creek, a tributary with a drainage area of about 38 square miles; hence it may be said that Cahokia creek enters the bottoms with a drainage area behind it of 226 square miles and a discharge of about 5,040 cubic feet per second. This area is more than double that of the entire flood-plain section drained by this system.

Flood-plain section. After entering the flood-plain, Cahokia creek flows nearly south to about Madison-St. Clair county line, then nearly west, passing through the city of East St. Louis and emptying into the river near the southern limits of that city. In a straight line the

length of the creek in the flood-plain is approximately 20 miles, but owing to its meandering course, the actual length is probably 40 or 50 per cent greater. Along Cahokia creek where its enters the flood-plain the average height of the surface is about 50. In the course of two and a half mile the bottoms have a fall of three feet to the mile, while the creek itself has a uniform fall of 1.5 feet to the mile, or three times that of the Mississippi. The bottom lands down to the Madison-St. Clair county line have practically the same average fall, their elevation being 26 near the county line. Southward from Cahokia creek, however, near this line, the entire bottoms from the bluffs to East St. Louis rise rapidly. Within the first mile they have an average elevation of 38, or fully 18 feet higher than the bottom of Horseshoe lake, which lies to the north.

Horseshoe lake acts as a storage reservoir for the flood waters of Cahokia creek, and thus protects East St. Louis and the country west of it. The effects of a heavy rainfall in this watershed would be to cause the stream to overflow its banks from the point where it enters the bottoms down to East St. Louis. As it is, however, the flood waters are intercepted at Horseshoe lake, spread out over it, raising its level, and then gradually flow off through the creek to the river. Notable examples of this were the high floods of June, 1902, and June, 1904. The first of these was caused by a heavy rainfall of 4.7 inches during 24 hours; the latter, by a local cloudburst in the upper watershed of the creek. The height of these two floods was nearly the same; that of 1904 being two inches higher than that of 1902. Along the creek the waters were confined within narrow bounds of the naturally high ground and a few small local levees, till about due east of Mitchell, where they passed the confines that had thus far held them in. They were poured out over the entire bottoms, and flowed west. north and south, augmented somewhat by a part of the water which had broken through a small levee near Poag, and also by the overflow from Indian creek. They practically covered about two-fifths of the entire drainage area of Cahokia creek in the flood-plain. or about 38 square miles. When it is understood that a large portion of this overflowed land was comparatively high and had not been covered by the water from the river since 1844, the seriousness of the situation may be appreciated. Land owners are endeavoring to fix the blame for this disaster on the various railroads crossing the floded area, and thus law suits aggregating several thousand dollars have been filed, with a prospect of many more. All this water flowed into Horseshoe lake and the bottom lands adjoining, with the result that its level was raised about six feet, or to elevation 32, as the lake already contained about six feet of water on account of the height of the river. This was the highest point ever reached by Horseshoe lake. From this increased height it has been calculated that the amount of water entering this lake was 2,000,000,000 cubic feet, or a little less than half that falling in the entire watershed, showing that about half became run-off.

Horseshoe lake is a basin comprising about 3.5 square miles. Its bottom is practically the same as that of Cahokia creek at the southern end of the lake, or elevation 20. It is never dry, having 18 inches to

two feet of water in the dryest seasons. This is because its bottom is below ground water level, which is described later. This lake bed is the lowest body of land in the flood-plain. The flood water reaches it not only through Cahokia creek, but also through Elm slough.

In addition to the water of Cahokia creek proper and of Indian creek, this system receives the water of the Madison county ditch which drains Grassy lake, also Judy's branch, School House branch, Canteen creek, Little Caseyville creek, and a few other minor drains flowing off the bluff. Canteen and Caseyville creeks issued from the bluffs just about at the summit of the divide between the Cahokia and Priarie du Pont drainage systems. Owing to the extreme flatness of the country in this vicinity and the peculiar locations of the streams, these creeks often flow in either or both directions, and as they are heavy silt carriers, their deposits have changed their course more than once. At one time both flowed north, but now all of Little Canteen creek, with much of its overflow, is going south. As both come from the bluffs between the Vandalia and Baltimore & Ohio railroads and have filled up the land between these two roads, and at the bridges crossing the streams to a depth of from two to eight feet, they have furnished the occasion for no end of law suits and contentions between the landowners and these railroads. Although the creeks flow south under the Baltimore & Ohio, they pass into Spring Lake and then back under the same railway again near East St. Louis into Cahokia creek, hence there is no question as to their classification with the Cahokia system.

PRAIRIE DU PONT CREEK.

Upland section. Prairie du Pont creek has its source in the upland, or rather it is formed by the confluence of several smaller streams which drain about 42 square miles in the southwestern part of St. Clair county. The longest of these tributaries rises ten miles from the foot of the bluff. In addition to Prairie du Pont and its small branches, Schoenberger and Brouilette creeks, respectively, drain a considerable portion of the upland above French Village and Centerville. The total discharge of these streams, as they debouch upon the flood-plain is 2,350 cubic feet per second.

Flood-plain section. The point where Prairie du Pont creek enters the flood-plain is eight miles south of the Baltimore & Ohio railroad, which is the northern boundary of the area that drains south into this creek. From this point the creek flows westward, approximately three miles, to the village of Prairie du Pont, thence southward a distance of six miles, paralleling to the Mississippi before entering the latter. On reaching the flood-plain Brouilette creek runs into Pittsburg lake, which in high stages drains southward into Prairie du Pont creek. In times of heavy rains Schoenberger creek fills up the lowlands and issues in both directions—south into Pittsburg Lake and north into Spring Lake. The dry weather flow, however, is mostly northward. In the bottom it has no well-defined channel and changes its course frequently.

The surface elevations of the Prairie du Pont drainage basin are not so pronounced as those of Wood river and Cahokia. From the ridge

or divide near the Madison-St. Clair county line mentioned above the land has a fairly uniform fall of one foot in 6,000 feet, or about one-half that in the Cahokia bottoms of Madison county. This fall continues southward to Prairie du Pont creek, when the land rises in less than half a mile to an elevation nearly as great as that just south of Cahokia creek. It then falls gradually to the south as far as Fish Lake in the southern end of St. Clair county.

The Cahokia district has a natural drainage channel, the creek running practically through its entire length, while the Prairie du Pont district lacks this feature. The grade of the creek and the land in the Cahokia district is 1.5 feet to the mile, or three times that of the Mississippi river. The grade in he Prairie du Pont district includes a series of lakes of various sizes, formed in part by the water issuing from the bluffs and being unable to flow away. On account of the slight fall of the land and the absence of any well-defined drainage channel this water gradually spreads over what is relatively high ground and forms lakes. Generally speaking, the low lands in St. Clair county, while they actually represent the same elevations as in Madison county, are relatively five to eight feet higher when compared with the grade of the river directly to the west. For example, Horseshoe Lake is at elevation 20, but is 16 feet above the low water of the river directly opposite, whereas Pittsburg Lake in St. Clair county is at elevation 22, but is 24 feet above low water of the river opposite, or relatively eight feet higher than Horseshoe Lake.

In the Prairie du Pont area the effect of heavy rainfall is much less serious than in the Cahokia district, since (1) there is much less volume of water to deal with, (2) numerous lakes act as reservoirs and thus retard the flow, and (3) Prairie du Pont creek seldom overflows its banks.

THE MISSISSIPPI RIVER.

At low-water mark the Mississippi river receives the drainage of Wood river, Cahokia and Prairie du Pont creeks. The mouth of Wood river is at low-water level, while those of Cahokia and Prairie du Pont creeks are respectively seven feet higher. Consequently, when the water of the Mississippi river is more than seven feet above low-water mark it backs up the tributary streams until it is offset by the water of these branches.

When the water of the Mississippi river rises 30 feet above low-water mark, the flood-plain is subject to overflow. In such cases the flood gates at the mouth of Cahokia creek are closed in order that East St. Louis and other riparian cities may be protected. When the river rises to 35 feet it is considered dangerous, for there is approximately only 10 per cent of the land of the flood-plain above this elevation. At the present time the lowlands are protected from overflow by strong levees near the river bank.

Notwithstanding these precautions, the river at times of heavy storm inundates the city. During the last sixty years the stage of the Missis-

sippi river has been above elevation 30 on sixteen occasions, and during the same period has been at or above elevation 35 in seven instances. The dates and heights of the latter stages are as follows: 1844, 41.4 feet; 1851, 36.6 feet; 1855, 37.1 feet; 1858, 37.2 feet; 1883, 39.8 feet; 1892, 36 feet; 1903, 38 feet. Of these, the elevations of 1844 and 1903 stand out prominently; that of 1844 covered the entire flood-plain, while in 1903 the water was held in check by various railroad embankments which have been constructed since 1844. The greater portion of the land between the Southern and the Baltimore & Ohio railroads in St. Clair county, and all the land east of the Chicago & Alton and north of the Litchfield & Madison railroads and Long Lake were protected from overflow in 1903. It sometimes takes months for the flood water to escape after an overflow.

SILVER AND RICHLAND CREEKS.

The eastern part of the district drains southward through Silver and Richland creeks into the Kaskaskia river which covers the southeast corner of St. Clair county. The drainage is generally sufficiently well developed to carry off the superfluous rainfall rapidly. A porous loess, which easily absorbs water, covers the western half of Madison county and the western part of St. Clair county as far east as the meridian of Belleville. The eastern part of these counties is overspread by a white clay which does not absorb the rainfall. The area of this southeastward drainage within the district has not been computed, neither has the discarge in cubic feet per second been tested. It is thought, however, that these will compare favorably with the several drainage systems of the district given above, since the rainfall and other determining conditions are about the same.

GEOLOGIC FEATURES.*

(BY CHESTER A. REEDS.)

INTRODUCTORY NOTE BY ISAIAH BOWMAN.

It may be said that the chief difference between the present day hydrologic engineer and that type of so-called water artist whose sole source of reputation is a divining rod lies in the fact that the former bases his conclusions upon carefully collected facts of climate, geology and topography, while the latter bases his conclusions upon a superstition. The one makes a scientific, the other an unscientific and even childish use of the imagination. If this fact is once thoroughly appreciated it will logically follow that no one will begin the perusal of hydrologic data, even from a standpoint so critically brief as the economic. without having first of all acquainted himself with at least the elementary and fundamental geological relations.

There is no escape from this conviction. Hydrology is today a science, and its field and office methods rest upon a few well-determined

* A detailed report on the geology of the St. Louis special quadrangle is now in preparation by Professor N. M. Fenneman. As this covers the greater part of the East St. Louis district, only those geological features which have to do with the water resources are considered here.

principles. The chief ultimate source of all ground water is rainfall. The amount of water absorbed by the earth will depend on many factors, among which are the slope of the land, the character of the soil, the amount and duration of sunshine, etc. The occurrence of the absorbed water within the earth, that is to say, the depth at which it may be recovered and the head in response to which it will rise, etc., depends upon the structure, texture and attitude of the absorbing rock. These well-determined principles lead inevitably to but one conclusion. We must study those geologic factors which function water supplies before we can appreciate the meaning of hydrologic data or arrive at a conclusion in any degree scientific.

In the following chapter the reader will therefore find described such geological facts as will help him to grasp the salient features of the geology of the East St. Louis district. In writing this chapter Mr. Reeds has kept constantly before him the idea of the control which these facts have upon water conditions and resources. It is hoped that the value of the report has been enhanced by constant but brief references to these conditions, even in the chapter devoted more exclusively to geology than water supplies.

Geologic Formations.

GENERAL STATEMENT.

Although the only rocks which outcrop along the east bluff of the Mississippi are thick beds of the Mississippian and Pennsylvanian (coal measures) series, it is necessary to consider some of the lower formations, since in drilling deep wells older rocks are encountered. The data, concerning these older rocks, however, are meagre, and come from the logs of the few wells reaching down 2,000 to 3,000 feet and from exposures outside the district.

ORDOVICIAN.

St. Peters sandstone. The lowest formation which has been encountered within the district is the St. Peters sandstone at the bottom of a 3,069 foot well at the Postel Milling Co's. plant, Mascoutah, Ill. This sandstone is of Ordovician age and is the source of supply for a large number of artesian wells in the northern and western parts of the State.* The quality of the water obtained in those regions is usually good, and is adequate for the needs of the small cities and towns. The water in the Mascoutah well, however, which flows at the surface, is brackish and unsuitable for domestic use. The sand and shale in which the deep water is found reach from the 2,898 foot to the 3,069 foot level. The sand is round, fine-grained and has the appearance of the St. Peters sand found in the northern part of State. Many well owners and some drillers misuse the term in applying to the sandstone members which occur higher up in the geologic section, particularly those at the base of the Mississippian series and the coal

*Leverett, Water Supply and Irr. Paper No. 144, U. S. Geol. Surv., 1905, p. 250.

measures. In this part of the state the St. Peters sandstone is deep seated and is usually not found higher than 3,000 foot level, or 2,500 feet below tide. For further data see a list of deep wells tabulated on later pages of this report, and a hypsographic map of the St. Peters sandstone of Illinois and western Indiana, by Frank Leverett.*

Stones River limestone. In the geological column this formation occurs just above the St. Peters sandstone. Whether it extends across the district above the St. Peters is not definitely known. It outcrops, however, on the west side of the Mississippi river at Sulphur Springs, Mo., where it is exposed at the foot of a talus-covered slope, a stone's throw from the base of the Trenton limestone. The section shows a poorly preserved, thin-bedded limestone, about ten feet in thickness, with Stone's river fossils. Two sulphur springs and one containing magnesia, sulphur, and a noticeable amount of salt issue from the base of the exposure.

Trenton limestone. Like the Stones river, the limestone does not outcrop within the district, but reaches under the Mississippi river and appears in the rugged hills along the west bank from Kimmswick, to Glen Park, Mo., and southward. Some exposures have been noted in a small area on the east side of the river, west of Columbia, Ill., where the limestone has been uncovered for a long time, many small cavities ranging from the size of a pea to that of an egg are scattered over its surface. In the cuts along the St. Louis, Iron Mountain and Southern Railroad the cavities in this limestone are not prominent; still they undoubtedly facilitate the passage of water through the stone. One large spring with a fine quality of water was found issuing from this rock between the Glen Park station and the Mississippi river. Another was found two miles up stream in the same horizon, four feet above low water mark on the Missippi river. This limestone is widely distributed in northern Illinois, and in the region of outcrops is a good water bearer. The drill has shown that parts of it in Western Illinois, buried deeply beneath later formations will yield strong artesian wells, so that at such points it is unnecessary to sink to the St. Peters or lower formations.*

In the region mentioned above, that is between Kimswick and Glen Park, Mo., and southward, the upper surface of the Trenton, locally called the Kimmswick limestone, presents a tangential unconformity, that is between the Trenton limestone on the lower side and the Richmond formation on the upper there is a marked unconformity developed parallel to the bedding planes, and therefore not determinable from the structural relations. It is known only from paleontological evidence, the receptaculities, Rhynchonella and bryazoan beds, respectively, appearing in contact with the Richmond formation in the course of two miles.

Richmond limestones and shales. This formation is the youngest representative of the Ordovician. It does not outcrop in the district but is found about twenty to twenty-five miles south of St. Louis on the west bank of the Mississippi river, in the vicinity of Kimmswick

*Leverett, Water Sup. and Irr. Paper No. 114, U. S. Geol. Surv., 1905, p. 250.

and Glen Park, Mo. Below it is in marked unconformity to the Trenton limestone, as the Lorraine, Frankfort and Utica formation are wanting. Above them is an even greater unconformity with the Kinderhook of the Mississippian, all rocks of both the Silurian and Devonian periods being absent. Notwithstanding these unconformities the formation is thin, being only from four to twenty feet in thickness. It is composed of a limestone at the base, twelve to twenty-four inches thick, with a yellow shale above. The shale is a variable quantity and is known as the Maquoketa shale. At the Goerz quarry and kiln at Glen Park, the Richmond is not more than four feet thick, being half limestone and half shale. At places in the shale outcrop it shows signs of having been worked over after deposition. This was probably done by the Kinderhook sea, since the Bushburg sandstone, the lowest member of the Kinderhook formation, lies immediately above. Two miles above Glen Park on the Iron Mountain & Southern Railroad, the Bushburg sandstone is wanting, and the next higher formation in the Mississippian series, the Fern Glen, rests on the Maquoketa shales of the Richmond.

Typical Richmond fossils are found in the limestone member, and while in the shale these remains are not so numerous, various forms of graptolites and fish teeth are found. Since the formation is quite thin in this locality it probably has little to do with the water supply. In Iowa, Minnesota and northern Illinois it is exposed over a broad surface and is more important. Its chief role in relation to water supply is as an impervious layer separating the different aquiefers.

SILURIAN.

Niagara limestone. There is no definite evidence in the deep well logs that Silurian rocks are present in this district. The Niagara limestone occurs on the slopes of the Ozarks in Missouri and Arkansas, and outcrops to the north of the area a short distance above the mouth of the Illinois river. In the last instance the region is separated, however, from the East St. Louis district by an immense fault, which extends across the Mississippi river into Missouri. On the Illinois side the fault line is covered with glacial material, yet for a short distance on either side rocks are exposed on the surface; Niagara limestone on the north and St. Louis limestone on the south side.

DEVONIAN.

Devonian limestone... The Devonian limestones are ordinarily poor water bearers compared with the Niagara, yet in certain localities they afford sufficient water to supply local needs. Their outcrop is also much more restricted than that of the Niagara, being confined to small areas in the western and southern parts of the State.*

*Leverett, Water Sup. and Irr. Paper No. 114, U. S. Geol. Surv., 1905, p. 251.

MISSISSIPPIAN.

The classification proposed by Ulrich* is followed in this report. Only the two upper formations of the Meremec group of the Mississippian series are exposed within the district. They occur in the bluffs at Alton and at Stolle, Falling Springs, and one mile east of Columbia. The rocks of the Osage and Kinderhook groups are exposed to the north and west along the Mississippi river, and in sinking wells are encountered within the area. The Chester group does not occur within the district, but to the southeast, on the east side of the Mississippi river; hence, it will not be considered in this report.

Kinderhook shale and sandstone. The Kinderhook group is composed chiefly of sandstones with the shales and limestones. It lies unconformably upon the rocks below and differs widely in its texture and in the arrangement of its sediments. During the time the latter were being deposited the sea varied in different places at different times; consequently the sandstone, shale and limestone formations are local in their distribution, producing a corresponding complexity in the occurrence of the water they bear. In the few wells reaching to these rocks an abundance of water is usually found, but it is brackish and unsuitable for domestic use.

Osage limestones. This group is composed almost entirely of coarse bedded limestones, Burlington and Keokuk, with minor amounts of shale. These rocks are replete with fossils and are wide spread, being well exposed near Hannibal and Louisiana, Mo. The average thickness of the formation in the southern part of the state is 200 feet. Within the area it is thought that they range in the thickness from 225 to 250 feet. Although they are wide spread and form a noticeable part of the geological column, they are poor water bearers by reason of their compactness.

Meramec limestones. The Meramec has been subdivided by Ulrich* into the Warsaw, Spergen Hill and St. Louis limestone. The first of these occurs in Missouri along the Meramec river near Valley Park, and again in the type locality at Warsaw. The Spergen Hill and St. Louis limestones are exposed within the district forming the high bluffs at Alton, Stolle and Falling Springs. They again appear in quarries one mile and one and one-half miles east of Columbia, on the road to Millstadt. About half way between Columbia and Millstadt, near the Monroe-St. Clair county line, the fourth line of deformation* occurs, the low arch representing this being completely covered over with the mantle of drift. From well sections, however, the dip of the northeast limb, in the direction of Millstadt, Belleville and Mascoutah, has been determined. The matter is discussed further in connection with notes on city and village water supplies.

These formations are distinguished by their fossils. They have certain lithologic facies, however, which aid in their determination. The Warsaw is composed of yellow shales and limestones; the latter being

*Ulrich, Prof., Paper No. 36, U. S. Geol. Surv., 1904, p. 24.
† Ibid.
‡ Weller, Bulletin No. 2, Ill. State Geol. Survey, 1906, p. 22.

thin bedded and predominating over the shales. The Spergen Hill formation is composed almost entirely of heavy massive gray to dark brown limestone, and is characterized particularly by the great abundance of small foraminiferal shells which have been mistaken for "oölite." This is the same as the Spergen Hill or Bedford limestone of Indiana, widely known as building stone. The St. Louis limestone is massive and quite flinty in the upper part. Wherever it outcrops or comes near the surface, sink-holes and caves are formed. Many of the great limestone caves of Kentucky and southern Indiana occur in this formation. In the vicinity of Burkville, Ill., Eckert's cave, supposed to be six or eight miles long, has been explored for some three miles. It abounds in funnels, rifts, waterfalls, underground streams and other features associated with limestone caves as stalactites and stalagmites. Between Stolle and Columbia there is a sink-hole and cave district from two to four miles wide. The Warsaw and Spergen Hill formations are not as good water bearers as the St. Louis, since they do not develop the cave features. In the vicinity of Belleville and Mascoutah the upper part of the St. Louis limestone is the first horizon in which salt water occurs. In the southern portion of the state these three formations attain a combined thickness of 200 to 245 feet. They are distinguished from the limestones below by their fossils and their finer texture. In the following table is given a section of the limestone in the Anderson quarry one mile above Alton on the Mississippi river:

	Feet.	
	Thickness.	Depth.
Loess	35	35
Limestone	14	49
Limestone, thin bedded (fossils)	5	54
Limestone	26	80
Limestone with shaly partings	2	82
Brecciated limestone (fossils in upper part)	27	109
Limestone with magnesian bands (fossils)	44	153
Talus slope (base of quarry to river)	30	183

PENNSYLVANIAN.

Coal Measures. The Pennsylvanian or coal measures formation occurs immediately beneath the mantle of drift, and extends over all the district except the western part of the Mississippi river flood-plain, locally known as the American bottoms, and the Karsted region mentioned above. In the American Bottoms the river sediments, which are from 100 to 150 feet thick, rest at Granite City on the massive bed of Mississippian limestone (see section of the Niederinghaus deep well at Granite City, No. 45), while at Monks Mound and near Peters they rest respectively on a shale and a sandstone which are undoubtedly Coal Measures strata. (See section of the deep well near Monks Mound, No. 37.) The line of contact between the Mississippian and Pennsylvanian formations in the American Bottoms is not known, but is probably somewhere between the eastern edge of East St. Louis and Monks Mound. It is reasonable to believe that at some former time in geological history the Pennsylvania formation once ex-

tended clear across the flood-plain of the Mississippi river, since Coal Measures rocks are found not only in the bluffs from Centerville around to North Alton and in sections of deep wells near Monks Mound and Peters, but beyond the Mississippi in the City of St. Louis and districts to the west and northwest. This was probably the condition in pre-glacial times, since geologists are agreed that the river trimmed the present bluff line previous to the glacial epoch.* The ice, however, may have materially aided the river to carve the present contour of its cliffs, since on the high bluff just above Alton one can see the former valley of three small streams along the line of unconformity between the massive Mississippian limestone and the loess. One of these is perhaps one-fourth mile across and twenty-five feet deep. These may have been carved out by the ice before the drift was deposited, since they are not large, have gentle slopes and occur in contact with one another.

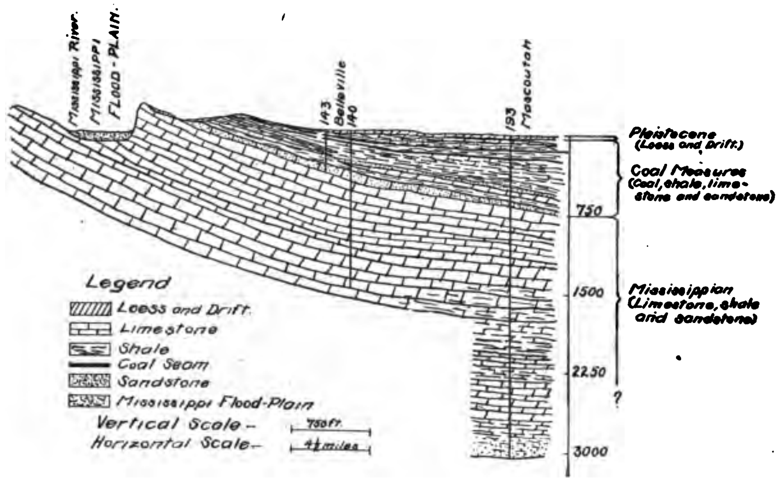

FIG. 2.—Geological section across the southern part of the East St. Louis district from east to west through Mascoutah, Ill., to Jefferson Barracks, Mo.

The formation is composed of alternating beds of sandstone, shale and limestone, in addition to a few grits and conglomerates and thick beds of coal. In conforming to the western slope of the eastern interior coal field these strata dip gently to the eastward. From the logs of the deep wells at Belleville, Mascoutah and those at Granite City, Monks Mound and Collinsville, two hypothetical sections have been made which cross respectively the district from west to east, all of the massive strata which were encountered in sinking the deep wells being represented. (See figures 2 and 3.) From these sections it will be

*Leverett, Mon. XXXVIII, U. S. Geol. Surv., 1899, p. 89.

noticed that the Coal Measures do not extend to the Mississippi river, and that the strata dip more sharply in the western than in the eastern part of the district. It will be noticed, also, that at the base of the Coal Measures a sandstone conglomerate is persistent throughout. This is the chief source of supply of the artesian wells at Belleville.

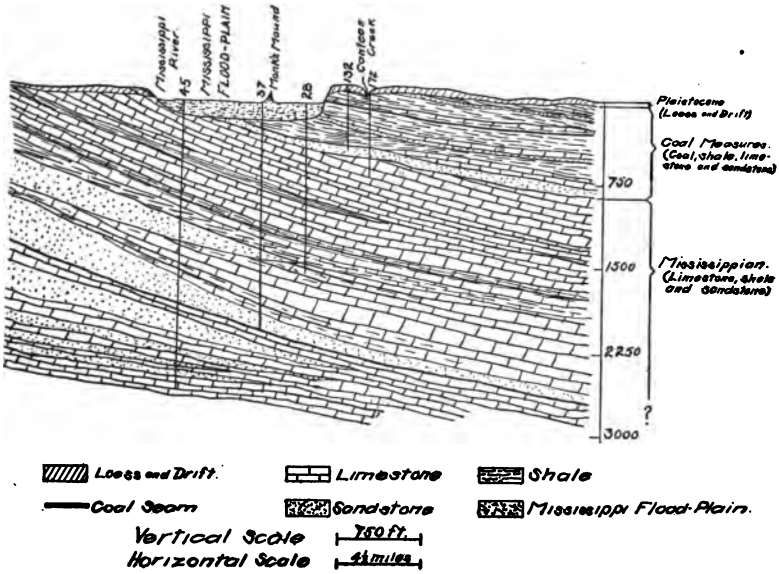

FIG. 8.—Geological section from east to west across the central part of the East St. Louis district, from 12 miles east of Collinsville, Ill., to 8 miles west of the Mississippi River, through the northern part of St. Louis, Mo.

PLEISTOCENE.

Till. The till, which is exposed chiefly in the southern part of the district is usually of a yellowish brown color to a depth of fifteen feet or more, beneath which it assumes a gray or blue-gray hue. In many places there is a transition from the brown to the gray in which gray streaks remain in the brown till, or cracks stained brown extend some distance into the gray till. In such places it is probable that the brown is simply an altered gray till, the oxidation of the air having produced the change of color. In places a thin bed of sand or gravel, which supplies water to shallow wells, occurs at the junction of the brown and gray till and gives them the appearance of being originally distinct. In such places, however, it is not certain that the brown till was not originally gray in color, this point being still unsettled. In Madison county typical till is found along the east bluff of the Mississippi river throughout the entire width of the county, as well as at points farther east. The till is usually twenty-five to fifty feet in depth, and where thickest is of a blue color near the bottom. On the east bluff, below East St. Louis, only a small amount of glacial drift has been found beneath the loess deposits which there cap the bluff to a

depth of thirty to fifty feet or more The drift usually consists of a thin bed of stony material, but in some of the recesses of the bluffs and in ravines, exposures of nearly pebbless clay or seen. Some of these exposures near Columbia, just south of the district, reach a depth of from forty to fifty feet. An occasional bowlder a foot or more in diameter is found in these deposits, but stones are very rare compared with their number in typical till, such as is exposed in the east bluff above East St. Louis. It is probable that the ice sheet extended as far west as the east bluff of the Mississippi in St. Clair, Monroe and Randolph counties, but the deposits there are very much thinner than in the drift ridges which traverse the eastern portion of these counties, and which perhaps mark an ice margin at a somewhat later period than that of the maximum extension.

Loess. The loess is not uniform in structure. A very porous deposit found on the borders of the large valleys has been called bluff loess, while over the plains between the streams a surface silt is found.

The structure of the loess varies in vertical sections as well as from place to place. The leading variations in the vertical sections are such as to support a three-fold division:

(1) The surface portion, two to four feet in depth, which has an earthy structure, due probably in part to the breaking down of many of the grains under atmospheric action. This phase characterizes not only the deposits on interfluvial tracts, but also those on the borders of the main valleys, as is natural if the earthy appearance is due to atmospheric action. (2) The main body of the loess is a silt, usually without definite bedding planes or stratification. It is somewhat more porus on the borders of the main valleys than beneath the interfluvial tracts. The variation in texture is apparently due to the removal of the finer material on the border of the valleys rather than to the presence of coarser material on the interfluves. (3) The basal portion, which comonly shows a more distinct bedding than the body of the loess, is in places sandy and pebbly. As a rule the pebbles are confined to the lower two or three feet, but in the thicker portions of the loess the well-defined bedding may occupy a depth of several feet. The pebbles often occur in places where the bedding is obscure; indeed the most distinctly bedded portions are usually free from pebbles.

In the following the loess from place to place across the interfluves, it is found to undergo gradual changes in texture and color, for which a cause is not in all cases manifest; but, as a rule, the more porous portions of the loess are found in proximity to a large valley. On passing back from the valleys the open texture becomes less pronounced and there is a gradual change to a loam of varying composition.

The entire surface of the Illinoian drift sheet appears to have received a capping of loess-like silt at about the time of the Iowan ice invasion, the deposit being found midway between the streams, as well as along their borders where it was first recognized. It is much thicker on the bluffs of the Illinois and Mississippi than on the divide between these streams or in the region east from the Illinois. In much of southern Illinois the thickness is only from three feet to five,

and the average depths in districts east of the Illinois and Mississippi is probably less than ten feet. On the borders of these streams its thickness is frequently from thirty to fifty feet. At the immediate edge of the Mississippi Valley above East St. Louis, there is a deposit from thirty to fifty feet in depth, but within ten miles back from the bluff the thickness decreases to ten feet or less. Below East St. Louis the loess caps the bluffs to a depth of from thirty to fifty feet or more. The till and loess are the source of the shallow well supply of water.

Recent Alluvial Deposits.

The alluvial deposits within the district are confined to the flood-plain of the Mississippi river. In this plain the sediments increase in thickness in going from west to east. At Granite City they are thick, 113 feet; at Monks Mound, 140 feet; near Peters, 150 feet. This material is composed of a heterogeneous mass of sand, clay, gumbo, shells, gravel, etc. In some places the sand is very fine, while in others it is coarse with grains of various rock as if glacial. The pebbles are of different sizes, and are often brown and yellow quartzite, greenstone, etc. Throughout the flood-plain the sediments are arranged in no definite order, but in sinking wells the larger materials, such as gravel and pebbles, are usually found near the bottom, while the smaller sediments, such as fine sand, clay, gumbo, etc., occur near the surface. In the geological section across the center portion of the district, Fig. 3, the arrangement of these sediments with reference to the other geological formations is shown in profile.

The possible arrangement of the sediments is shown in Fig. 4, which was made for the Missouri river, but which will serve to illustrate the Mississippi on the margin of the district.

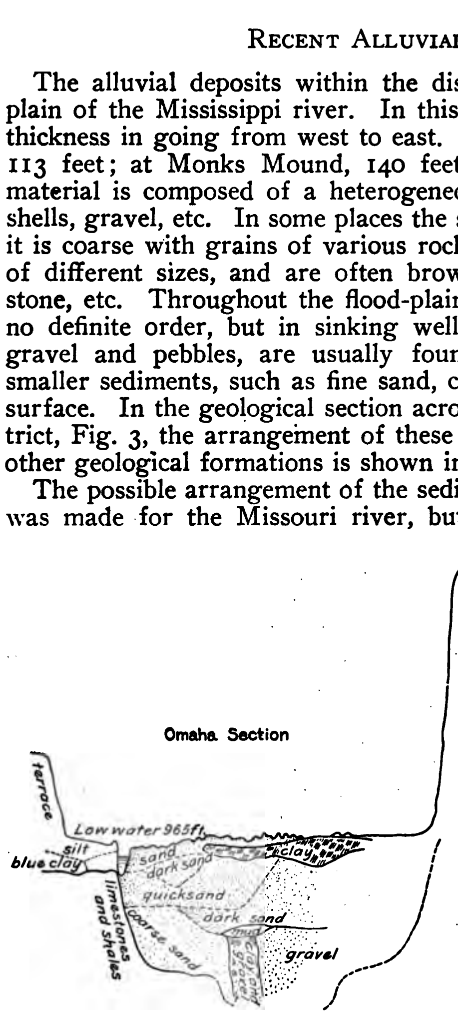

Fig. 4. Diagram to show the heterogeneous character of alluvial deposits. [After Todd. Republished by the courtesy of the U. S. Geological Survey.]

Mississippi river. These sediments have been deposited as a heterogenous mass by the action of the Mississippi river and its tributary streams. The ice may have filled in a portion of the material, yet from the information at hand it is more rational to believe that the river and tributaries brought in the material from the thick glacial deposits which cross the river higher up and from the bluffs nearby. From sections of 25 shallow wells in East St. Louis it can be seen that the ground upon which the city stands is identical with the deposits which the river is making along its course at the present time; one instance is in evidence as going to show that

the Mississippi river is building out the flood-plain between the old town of Cahokia and the present channel of the river. All the land west of the town, one mile in width, has been deposited within the last fifty years; for in 1850 Cahokia was on the bank of the Mississippi. This filling in of the river has been aided materially by the Mississippi River Commission, which has placed hurdles along the east bank every few hundred feet. These throw the current of the river to the west bank, allowing sediments to settle in behind them. The flood-plain is extended not only by adding to the bank, but also by flood waters rising and flowing over the plain at repeated intervals.

In the flood plain the average level of the land used for agricultural or commercial purposes is from thirty to thirty-five feet above the low water of the river directly opposite. Of this kind of land there is probably not more than 10 per cent. During the past sixty years the stage of the Mississippi river has been above elevation 30 on sixteen occasions, and during the same period been at or above elevation 35 on seven occasions. The dates and heights of these seven extreme stages are as follows: 1844, 41.4 feet; 1851, 36.6 feet; 1855, 37.1 feet; 1858, 37.2 feet; 1883, 34.8 feet; 1892, 36 feet; 1903, 38 feet. That of 1844 was the highest and covered the entire area of the flood plain, since at that time there were no railroad embankments to obstruct its flow. The flood of 1903 would probably have covered as large an area were it not for the railroad embankments which have been constructed since 1844. The greater portion of the land between the Southern and the Baltimore & Ohio railroads in St. Clair county, and that east of the Chicago & Alton and north of the Litchfield & Madison railroads and Long Lake, in Madison county, was thus protected from the overflow of 1903. The amount of sediments left upon the land after such an overflow is greatest in thickness in the vicinity of the bank, since the current is checked there and the material precipitated. The total depth of repeated overflows amounts to several feet, which is very important in a flood plain of this character.

Tributary Streams. In addition to the Mississippi river, the small tributaries which come out of the bluffs on to the flood-plain deposit a considerable amount of sediment. Usually these sediments are thrown down near the bluffs along the courses of the numerous creeks. They are, however, of sufficient importance and length to block and change the drainage of some of the lower lakes. The outlet of Pittsburg lake to the south has been largely closed up by bluff sediments of Druitt creek. In 1886 a dense jungle of willows, one-half mile on either side of Schoenberger creek, extended from French Village to Spring lake. It is now a good truck farming country, free from any danger of overflow from the Mississippi.

SURFACE SOURCES OF WATER SUPPLY.

(BY ISAIAH BOWMAN.)

USE OF RAINWATER.

CISTERNS.

Construction. Cisterns for supplying drinking water are in use in various places in the East St. Louis district. They are usually from sixteen to eighteen feet deep and from eight to twelve feet in diameter. They are made of double rows of well mortised brick, cemented on the inside to a smooth surface. As thus constructed, they are water tight and keep out all impurities except at the top; hence, are often built either directly beneath or adjacent to the house of the owner, whose drainage from the roofs can readily be turned into them.

Use and advantages. Many people living in the Karst district, where the limestone is extensively caved, regard the Karst water as unsafe, not from any thought of the hydrologic conditions, but from the alleged fact that when certain families in which typhoid fever was an annual occurrence ceased to use well water they ceased to have typhoid. That fever should follow the use of the karst water in many cases is not surprising, in view of frequent close proximity of cess pools and wells and the excellent facilities for direct drainage from the one to the other. To one unaccumstomed to the idea the using of cistern water seems at first thought obnoxious; but, considering the manner of construction and the fact that the cisterns are regularly cleaned—once or twice a year—most of the objections disappear. The impurities removed in cleaning the cisterns consist chiefly of sand and dust blown on the roofs of the houses and washed in by rain, or if near a city, of coal dust. The later is thought to act as a filter, and its collection in the cistern is rather favored. The water collected in the cistern is that resulting from winter rains. This comes into the cistern at a low temperature and is kept cool through the summer by the ground under the cistern bottom, which is perhaps never below 50° F. and never above 60° F., even in the hottest weather. If water that falls in summer is collected, it is usually of a yellowish color and very warm and unpalatable. The capacity of the cistern is great enough to enable the owner successfully to husband the winter supply through the following summer, as the water is used for drinking purposes only. Cisterns for the collection of water for washing purposes are usually of separate construction.

Recommendations. It is not commonly known how much more palatable than summer water winter water is. Only one who has tried the two classes will be convinced of the desirability of excluding the rain water of summer. Besides the matter of taste and color, it is known that the rain water of summer is likely to contain a much higher percentage of organic matter collected from the roof of the house, and that this matter by decay is likely to still further vitiate the quality of the water. Winter water should therefore be preferred. It is also

recommended that cisterns be cleaned oftener, especially in summer, when a large amount of germ-laden dust is carried aloft and deposited on house tops. With the help of a candle the cistern wall and bottom should be examined thoroughly at each cleaning to detect the presence of any cracks which may have formed and which may allow the entrance of and pollution by ground water or by karst water.

Water Supply From Springs and Streams.

SPRINGS.

Disribution. No springs of significance occur within the East St. Louis district except Falling spring (B 6, Plate 3) which in a certain sense is not a spring at all but merely the appearance at the surface of an underground stream. In the ordinary acceptance of the word "spring" it embodies or connotes the idea of the slow but relatively concentrated issuance of water from saturated sands or gravels of rock. The spring discharge in some sections, as for example the northern shore of Long Island, N. Y., is so great as to be of economic interest to a concentrated population nearby. In this case the interest is increased to an unusual degree by the further fact that the springs discharge almost directly into the sea, and to be utilized must be recovered at the point of discharge. Ordinarily, as in inland sections, the springs are the source of supply for brooks and rivers, and interest in them is chiefly through their relation to the surface drainage. Such is the case in this part of Illinois, except for the one noted.

Utilization of spring water. Springs are often of great value in special cases. They frequently ooze out of a river bluff or valley side in hundreds of places and mark the intersection of the water table with the surface. Wells sunk here are in saturated material throughout their entire depth and not a fraction of their depth as ordinarily. Hence the whole well wall is a bleeding surface. Such water has passed through a natural filter, the soil, for some distance and has been acquired before it reaches the river and becomes liable to contamination. Many villages in Michigan are supplied by water systems dependent on wells sunk in these favored localities, and it would seem to be an important resource in the East St. Louis district in the future when surface streams are rendered more important, as there is a steady increase in the density of the population. A further advantage of this system lies in the cheapness with which the wells may be driven. Common well points with long screens purchased for a few dollars and driven down with 2-inch or 3-inch drive pipe, are often sufficient. Indeed, where the water-bearing material is coarse it is sometimes the case that no special screen is used, the whole drive pipe acting as a screen, being perforated throughout its entire length with ¼-inch holes.

The localities which are best suited for the development of such a system are those where a valley has been incised below the level of the water table. Springs appear at the surface on the line of intersection of the water table and the valley side. The upland bluff in the East St. Louis district is such a locality as well as the valley sides of most of the larger streams tributary to the Mississippi in this district.

Streams.

GENERAL STATEMENT.

The principal source of stream water within the East St. Louis district is the Mississippi. Besides this there are smaller streams, tributary to the Mississippi, which may be drawn on for a supply. On account of the importance in many connections of the Mississippi river in this district, we shall describe in considerable detail its relations to the problems of water supply.

Mississippi River Water.

DIFFICULTIES IN UTILIZING.

Popular view of availability. In view of the fact that the water derived from the flood-plain deposits can not be used in boilers in its natural condition, that is to say, without the application of a compound to prevent scaling, and that a water supply serves the manufacturer chiefly for boiler and cooling purposes, it would seem that river water could readily be substituted to the relief of the situation. To most people the idea of using river water would seem to be the easiest possible feat, to require merely the laying of a pipe line from engine room to river bank. To such it will seem a surprising statement that the gravest general problems and most serious mechanical difficulties in the whole East St. Louis district which up to the present time have been met and overcome, are those involved in the acquisition, cleansing and delivery of the water of the Mississippi.

Pipe line to the river. In the first place, manufacturing plants are rarely located on the bank of the river, most of them being from one to three miles back. The cost of laying a pipe line in the latter case is great, but not prohibitive; the chief difficulty is not the cost but the securing of the privilege from the city and village councils of the right to undertake construction of this sort. One of the first considerations in towns located on the flood-plain is that of protection from overflow in times of high water on the Mississippi. For this purpose levees are constructed and carefully guarded from burrowing animals and man. A telegraph company recently failed to secure a franchise from a town near East St. Louis for the construction of a telegraph line involving the planting of poles across a levee. It was held by the town council that in time of high water on the outer side of the levee the pole hole on the inner side might operate on the principle of a sand boil, the water rising slowly at first and then faster until a passage was excavated which might later undermine the levee. Such cases are not unknown and the objection appears to be valid.

To such interests there would be but one answer to the question of the building of a pipe line through a levee in the ordinary manner. It would offer facilities for the movement of water under the levee between the pipe line and the earth about it, and therefore constitute a source of danger from overflow. Such lines have indeed been built by water companies, but always according to specifications which look toward the prevention of this evil and in locations which offer the least

number of chances for its occurrence. Both the telegraph and the water supply system are public utilities of a transcendent order, but in the former case the varieties of manner by which the line can be inexpensively run in different places far exceed those in the latter case, and it cannot therefore be admitted that the two stand on equal terms in this connection.

Problems of System as Illustrated by City Water Company.

The various other difficulties and problems which arise in the attempt to use river water may best be understood from an account of the experiences of the City Water Company of East St. Louis and Granite City, and the conditions under which these two plants are maintained.

GRANITE CITY PUMPING STATION.

Location. The pumping station for the Granite City division of the company is located on Cabaret Island, as shown in Fig. 5. The river is reached by a suction main 200 feet long, on the end of which is attached a strainer with 2-inch openings. From the map, plate 4, it may be seen that Cabaret Island lies on the inside of a bend in the river. The cutting on the outside of the bend or on the west bank of the river at this place is compensated by additions of material on the low sandy inner bank. The successive additions are clearly shown in plate 4, as well as the chutes or remnants of the old channel, which have now been superceded by a newer western one. The district is therefore one of filling, and, as might be expected this embarasses the company in the use of the suction main.

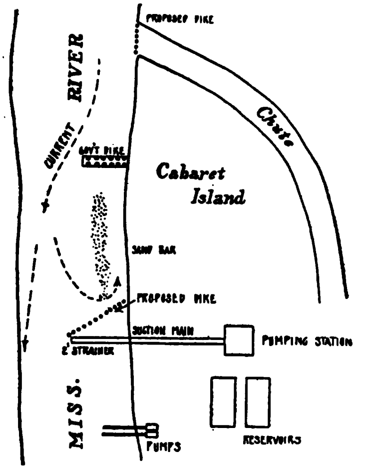

FIG. 5. Cabaret Island and Granite City pumping station of the city water company

Difficulties of maintenance; shifting sand. For protection in high water the Mississippi River Commission has built a dike at the point shown below the intake of Cabaret chute. In the lee of this dike an eddy forms, and river-borne material is in consequence deposited. The sandbar has grown southward steadily until it is at present seriously menacing the suction main which crosses its path. The danger is greatest at times of falling water following flood, when the volume of the stream rapidly decreases in proportion to its load, and banks and bars grow with incredible rapidity. In the present case the condition is aggravated by the fact that in time of high water a part of the current escapes by way of Cabaret chute, whereas if it were retained wholly in the main channel deposition would not take place so rapidly, by virtue of the law just referred to. To accomplish

the desirable end of retaining the whole volume of the stream in the main channel, a dike has been proposed, to be built at the entrance to Cabaret chute, Fig. 5, and this will no doubt be an effective remedial measure.

A second project, which but little commends itself to the writer, involves the building of a dike between the lower end of the encroaching bar and the suction main. This would, however, offer conditions equally favorable to the formation of a bar as those further up stream. Meanwhile the situation has been partly relieved by cutting a gap through the government dike, as shown in Fig. 5, and allowing part of the current access to the bar. This counteracts or breaks up the eddy and partially removes the accumulated material.

Whenever the sand accumulates in such amounts as to close the suction, a diver (steadily maintained in the employ of the company) cleans it away. The sand has also been removed by anchoring a scow over the end of the main. The deflection which the shape of the bow and bottom of the scow gives to the current concentrates more powerful threads of the current on the bottom than under natural conditions and bottom scour results. It is difficult to direct this action, however, except in a rough way. During the time that the main suction line is choked with sand, water is obtained by the use of smaller suction mains south of the principal one. These are operated by two small auxiliary pumps on the bank of the river.

EAST ST. LOUIS PUMPING STATION.

Location. The East St. Louis division of the City Water Company has its pumping station just within the main levee at the northern end of the Terminal Association's switch yard in East St. Louis. Two separate power houses are maintained here within a quarter mile of each other, the one at the intake, which pumps water from river to reservoir, being called the low pressure station; the one which delivers water to the city from the reservoir and furnishes pressure for fire protection, being called the high pressure station.

The power house ends of the suction mains are in a pit 20 feet below the surface, entering the pit a few feet above the bottom. One of these mains has a diameter of 20 inches, the other 30 inches, and both extend through a tunnel a few hundred feet westward to the bank of the river. The tunnel feature of the mains enables workmen easily to examine any part of the intake at any time (or to make repairs), a circumstance of considerable importance in view of the liability of overflow at the surface to the prevention of any excavating in case of breakage or leakage in the mains.

River connections. The mains pass through a check built into the bank below the upper level of the rip-rap and extend for 250 feet into the river and from 10 to 20 feet below the surface of the water. They are supported by 12 hog-chains strung between 12 pair of piles and terminate in 8-foot screens or strainers.

Each strainer is punched full of holes about one inch in diameter. The strainers are constantly being clogged by river-borne detritus and

the diver in the employ of the water company is kept pretty constantly employed in cleaning off the accumulated material. This consists chiefly of grass, leaves, roots, etc. The character of the material reflects in an interesting way the prevailing conditions on the river. In the autumn season when the trees along the bank of the Mississippi or its tributaries are shedding their leaves into the stream, the material is chiefly dead leaves or twigs; but at times of high water in late spring or early summer the material is chiefly grass and roots dislodged from the river bank on the outside of bends where cutting is then actively in progress.

A second strainer is inserted in that part of the mains which is in the pit of the power house. The manner in which this strainer is inserted, as well as its shape, are shown in Fig. 6. The mesh is considerably finer than that in the river strainer, being ¼-inch as against 1 inch. The power house strainer is intended to strain the water of all, or nearly all, the rough material before it enters the settling reservoirs. So rapid is the rate of accumulation of this material that the strainer must be removed and thoroughly cleaned once a day, a feat requiring the labor of three men for at least two hours. A square section of main, as indicated, receives the cone-shaped strainer, which is removed and cleaned by removing the bolts and iron top on the upper side of the main.

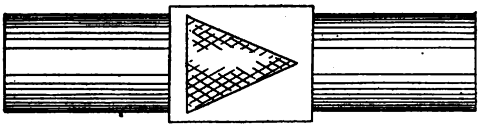

FIG. 6. Cone strainer of fine mesh in suction main, City Water Company of East St. Louis.

A check valve in the mains prevents overflow of water into the pit bottom while this operation is being conducted. Such overflow is the result of a natural head at some seasons when the river is higher than the bottom of the pit. The natural head is never great, however, usually expressed but a few pounds per square inch.

Difficulties of maintenance. The same difficulties with bank sand and mud are here experienced as in the case of the pumping station on Cabaret Island. At high water the river widens and the mud line* is carried farther up the bank and farther away from the center of the channel. Mud and sand are deposited on the rip-rap or revetment and in the suction main, frequently in the latter case to a depth of several feet. At low water a large share of these deposits are again removed, as the zone of scour encroaches on the zone of deposition, but meanwhile the strainers must be uncovered in response to the urgent need for a continuous supply of water in the delivery mains. The engineers of the water company always keep a jealous eye on the river, and never cease making soundings and other explorations that inform them of treacherous muds and sand banks which may at any time encroach on the strainers and bury them, and thus tend to shut off the water supply of the city.

*The name given to the boundary between the lower zone of bank deposition and the upper zone of bank scour.

Cleansing processes. The strainers connected with the mains of the low pressure power house remove only the coarser impurities of the river water. In color and as far as fitness for use is concerned the water is identically as when first drawn. No further description of it is needed for those who have ever seen the Mississippi: one of the most noble rivers in its proportions, it is one of the most unsightly in detailed appearance, its dirty tide of yellow water always bearing enormous quantities of the silt and loess and other materials constantly delivered to it from rain-swept fields somewhere in its great basin. Before the water can be delivered to the city hydrants it must pass through a long and complex process which we shall now describe.

From the low pressure plant the river water is pumped through several 30-inch mains to two reservoirs, where it is ejected through 32-inch aerators, 16 in each reservoir. The aerator is nothing more than a pipe placed in a vertical position, the water being forced to come out of the top under a low pressure, so that it spills outward and downward in a thin, roughly cylindrical sheet or film. By this means the water is pretty thoroughly aerated except when the wind is blowing heavily and the film is broken up into more concentrated forms. A capping of wood would prevent this, but would allow of less perfect contact of fresh air and water, and the present arrangement therefore seems best. By aeration the carbon dioxide, free and combined, is removed.

Once in the reservoirs the water is parted from still more of its impurities by a process called "baffling." Partitions project from one side of the reservoir almost to the opposite side and the water is "baffled" by being forced to pass around the ends of the partitions. The movement is slow and tortuous and large quantities of sand and mud held in suspension up to this time are now deposited by reason of decrease of velocity and, therefore, of carrying power. The amount of sediment deposited in the bottom of the reservoirs decreases as one passes farther from the aerators, where its journey begins. On the side of the reservoir opposite the aerators the baffled water spills over the edge of a trough in a thin film. By this means only the pure water from the top is drawn off, and, spilling in a film, is still further aerated.

From the first set of reservoirs the water is now delivered by gravity mains to a second set of reservoirs where it arrives very much improved in general appearance but still discolored. It should be said here that the reservoirs of the whole system are so arranged that from the time the water escapes from the aerators until it has been received at the filters it is moved solely under the influence of gravity. In the second and much more extensive set of reservoirs the water is again baffled and arrives at the exit very noticeably clearer and purer, although still slightly murky. It is here injected with a solution of lime and sulphate of iron which precipitates some of the remaining impurities.

The next step in the purification of the water and one looking toward the complete removal of all silt and mud is filtering. The general features of the filter employed by the City Water Company consists of eighteen cylindrical filters of the kind represented in the accompanying figure and eight tub filterers different in shape from the former but operating on precisely the same principle.

The cylindrical filters, Fig. 7, consist of an iron shell made up of sections riveted together, the whole 28½ feet long and 12 feet in diameter. Twelve inches below the top of the inside of the filter is a pan into which water pours from an eight-inch supply pipe called a "riser." The supply is maintained at the point where the water spills gently over the edge of the pan. A foot below the edge of the pan is a layer of sand 3½ feet thick. The sand used in this process is the so-called filter-sand obtained from the river bluffs at Red Wing, Minnesota. It is sharp, medium to fine sand, light yellow in color, and quite free from clay or silt. A sand combining all these qualities is not common, but it could possibly be supplied from somewhere within the borders of the State if the demand for it were known.

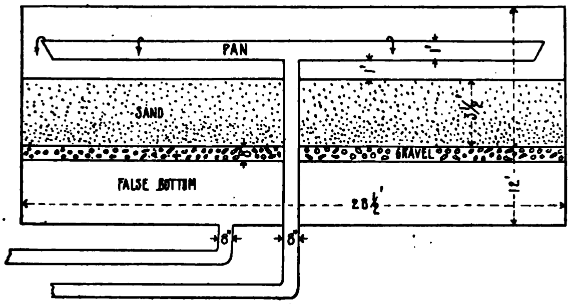

FIG. 7. Sand filter employed by the City Water Company of East St. Louis and Granite City in purifying water.

As the water passes through the layer of filter-sand and a layer of coagulant the water appears on the under side of the sand-bed quite clear and pure. We have here the counterpart of natural conditions of seepage through sand, the beneficial effects of which are well known. Below the sand layer is a bed of gravel, eight inches thick, resting upon a false bottom in the cylinder. This false bottom is pierced b· 800 holes in each of which is set a two-inch screen, similar to the Cook screen so well known in this section. It is not intended that these screens or the gravel packed about and above them should play any part in the direct purification of the water. The screens merely prevent filter sand from entering the space between the false and true bottom and the gravel enables more rapid delivery of waer to the screens as well as serving to a certain degree the same function as the screens. The water accumulating in the bottoms of the cylinders drains through eight-inch mains tributary to a thirty-inch main which empties directly into the reservoirs feeding the delivery mains that supply the city.

After being used for twenty-four hours the filters become clogged and must be cleaned. Usually only the top foot of filter sand is muddied and never more than two feet. In consequence of such clogging, the filters are back-flushed, preferably at night when the demand for water by the city is at a minimum. This is accomplished by adjusting a system of valves so that one filter only out of the eighteen is out of use at a time. Instead of allowing the filter to contribute to the supply, pure water is now forced into it from the delivery reservoir, the direction of the current being the reverse from that shown in figue 7. At the same time the eight-inch main that leads from the pan

downward is connected with the sewer. With these connections water is pumped through the filter under low pressure in order to prevent the tearing up of the sand bed and its mixture with the gravel below. The back-flushing requires about five or ten minutes when the water runs practically clear. It is a novel sight to watch the change when back flushing begins, the muddiness of the water bearing witness to the effectiveness of the filter during the preceding twenty-four hours. It is not necessary to carry the process to the point of absolute purity of the filter sand, since this would require much longer time without any effect on the purity of the water after filtering had been resumed.

When the operation has been completed the original connections are made except that the sewer connection is maintained for five minutes or more until all the mud dislodged in the filter sand by another change of current has been removed. The sewer connection is then broken and the water turned into the delivery reservoir.

The capacity of the eighteen cylindrical filters is one-half million gallons each in twenty-four hours. The capacity of the tub-filters is 400,000 gallons in twenty-four hours.

The water is treated chemically before delivery to the filters by what is known as the lime and iron process, sulphate of iron and hydrate of lime being used. In the autumn when leaves drop into the river and discolor the water the users object to the yellow color. Alum or sulphate of aluminium is then used, as it removes the color. The water company's chemist, Mr. Snell, says that he dislikes the use of this chemical and employs it only when forced to do so, and then only sparingly and for a short season.

CONCLUSION.

A thorough consideration of all the problems and processes involved in the foregoing discussion will convince one that it is no light undertaking to render Mississippi river water fit for use. It will be seen that unless a company is using a very much greater amount of water than any in this district, it cannot expect to maintain a filter plant with any hope of reasonable returns.

The City Water Company has undertaken and is successfully carrying out the plan of serving its clients with clear, pure and palatable water. Its engineers and chemists have mastered many difficulties and are entitled to great credit.

If the demand for the cheapening of the cost of water to the user is to be met, relief must be found by the use of economic and political means which is not possible to discuss in this report.

WATER SUPPLY FROM TRIBUTARY STREAMS.

General statement. The principal tributary streams of the East St. Louis district are the Wood river and Cahokia and Prairie du Pont creeks which are described in detail on earlier pages. They will be considered here, together with the tributaries, as a source of potable water.

Sources of pollution. One of the most important considerations in proposing the use of stream water is that of possible pollution or contamination from the sewage of towns located along the stream courses. A glance at plate 4 will show that none of the tributary streams in this district are bordered by towns or villages of any consequence in this connection. The largest city, Belleville, is located on Richland creek, which drains south and does not cross the district. A few unimportant villages are located here and there on the tributary streams, as Peter on Judy's branch and Caseyville (population about 500) on Canteen creek. None of these has a sewage system and none is therefore a direct source of pollution to stream water. The polluting material drains underground and is at least partially filtered through seepage before it reappears in the surface drainage. Sewage is a much more serious menace when it is delivered to streams in concentrated form by the establishment of a sewage system. Only the most careful analysis of the water and filteration will save it under these conditions, and then only when the water is extracted a considerable distance below the source of pollution. Just what this distance must be in an individual case can only be determined from observations on the ground. It will depend in part upon the ratio of the volume of sewage to the volume of the stream, the increase in volume down stream by accessions of water from tributaries, the amount of sediment carried in suspension by the stream, the velocity of the current. the natural aeration of the water by falls and rapids, etc.

Varying turbidity. The greatest difficulty in using the water of the smaller streams in this district lies in the irregularity of volume and the rapid change in quality which takes place during and after sudden downpours of rain. If we turn to a region where hard sandstone or granite outcrop over most of the catchment area of a given stream, as in some glaciated regions (within the areas of denudation), we shall find the water of that stream singularly clear and pure, even during periods of rain. There is in the assumed case either an absence of soil or but a thin covering in favored localities, and but little material is dislodged and contributes to the stream to make it roily. In the East St. Louis district, on the other hand, there is a heavy covering of loess and drift and the former acts with especial efficiency by virtue of its lightness and corresponding tendency to remain afloat or suspended when once in the power of the stream. Every rain storm that passes freshens the ravines, gashes anew the fields barren from the plow and thickens the streams with land waste, washed down rivulet and gully. The streams in question are, therefore, alternately relatively clear and excessively turbid. Any filter plant utilizing this water must, therefore, be as elaborate as to detail as if the streams were constantly turbid. It would be difficult also to maintain the suction pipe with such rapid and great changes in the level of the water and the consequent sudden and great changes in the level of the bottom of the channel near which the suction pipe would have to be anchored in periods of low water. Up to the present no use has been made of the water from these tributary streams, but it is extremely probable that such will be the case in the future. The difficulties to be overcome in its use

are no more serious than those in attempting to use water from the Mississippi; indeed, not so serious, perhaps, as they are chiefly financial, not mechanical. The use of this water would involve the careful protection from sewage or pollution from manufacturing wastes of the upper part of the watershed furnishing the supply. This responsibility would be greater than in the case of the Mississippi water, for two reasons: First, because the volume of the tributary during most of the year would be small and would thereby offer a poorer opportunity for the extreme dilution of sewage and other wastes than is offered by the great Mississippi; and, second, the amount of sediment carried by the small streams is by no means constant, and, except for wet periods when the small streams are in flood, is not great enough to collect the waste to an extent that such sediment collects waste in the Mississippi. In the process of sedimentation the precipitated sand and silt undoubtedly drag down finely divided waste substances which would require by themselves a longer period of time to settle. It cannot be shown that the mere presence of the sediment in the water assures cleansing unless sedimentation is enforced. The sediment is effective as a purifier only when allowed to settle and carry down with it the injurious solids with which it comes in contact.[1]

WATER SUPPLY FROM LAKES AND RESERVOIRS.

LAKES.

Position and characteristics. There are a few large lakes in the East St. Louis district of value as a source of water supply. They are almost exclusively of the type noted on earlier pages; *i. e.*, ox-bow lakes or bayous formed by cut-offs in meander curves. Their characteristics as to shape and position have already been described.

Present use. At the present time but little use is made of the bayou water. The Excelsior Tool and Machine Company of East St. Louis, whose plant is located near the western end of Pittsburg Lake, sometimes uses the lake water, but depends mainly upon water supplied by the City Water Company. Both waters scale the boilers, the bayou water more so than the city water. Water from the bayous is occasionally used for fire protection, plants located on or near the banks having hose connection with the bayous for the purpose.

Character. The bayou water is never clear and must consequently be filtered to be used for most purposes. Ordinarily a lake is clear except at the intake, where muds carried by tributary streams are in process of settling to the bottom. Deposition takes place as the water moves slowly out toward the central part of the lake, and the stream issuing at the foot of the lake is ordinarily clear and pure in contrast to the contributing stream. In other words, the lake acts as a filter in the course of the stream. The filtering process is exhibited in the case of the bayous or ox-bow lakes, but is not complete on account of the extreme turbidity of much of the water delivered and the high percentage of very fine, light and impalpable material derived from the

1 Mason. Water Supply, 1902, p. 26.

loess. Before much of this material has settled to the bottom, the supporting water has moved to the point of discharge, and is therefore still roily and unfit for use. The ox-bow lakes contain dark, muddy water. Their draining stream has the same characteristic, although it is true that they are distinctly clearer than the water delivered at the intake. (See later pages for mineral analysis of this water.)

Future use. By the process of sedimentation the bayous are gradually being filled up. Some of them have all but completed this change, marshy tracts marking their former position. The process is a rapid one and of interest in this connection chiefly because once filled up, the ground water, even though present in large amounts, cannot be recovered on account of the fineness of much of the material deposited in the bayous. Screens could not restrain this material and successful wells would be obliged to penetrate the filling and reach the coarser material collected in the channel bottom during the period when it was in active connection with the river and the scour of the current swept away the fine material.

Conclusion. On the whole, lake water is not a satisfactory source of supply in this district, for in addition to the above disadvantages there is often a rank growth of aquatic vegetation along the banks and even on the surface of the water. Its decay adds to the unwholesomeness of the water, and, indeed, its very presence shields the water from the beneficial effects of sunlight. Stream or well water will, perhaps, always be used in preference to lake water in this area, except in limited amounts in favorable localities, where the lake water offers a desirable resource in fire protection.

RESERVOIRS.

Present use. In a few cases—for example, Glen Carbon and Belleville—the water of streams is impounded in a reservoir. In the former case the stream known as Judy's branch is dammed and the water used in the boilers of the engines which operate the coal washers and hoisting apparatus. It is also employed in the coal washers themselves. At Belleville sma tributaries of Richand creek have been dammed and the water used in the boilers of the Star brewery, and it is occasionally pumped into the city mains. At Edwardsville a small stream has been dammed so as to produce a reservoir of three and one-haf acres in extent and yield water for coal washing. The reservoir water scales the boilers. The scale has been analyzed with the following results:

	Jan. 10, 1906.
Organic and volatile	5.9%
Calcium sulphate	90.6%
Magnesia	2.0%
Silica	1.5%

Physical characteristics: Thickness 7-64 in.; hardness, "very hard;" structure, crystalline and amorphous.

Analyst: W. P. Keefaber, Philadelphia, Pa.

Except in the case of Belleville the reservoir water is nowhere used for drinking purposes, and even in this case to a limited extent only at infrequent intervals. Just beyond the southern limits of the East St. Louis district reservoirs are a more common feature of water supply and a few notes on them may be of interest here.

Waterloo system. The village of Waterloo is equipped with a water system dependent on a reservoir two miles south of the village. The chief object of the system is fire protection, although about 200 citizens use the public water for drinking and other domestic purposes. About 1,000,000 gallons are pumped to the village daily. The reservoir is several acres in extent. It is supplied by water from springs and seepage at the source of a small tributary of the Kaskaskia river. It is divided into two sections, an upper and a lower, the pumping station being located at the foot of the lower section, where a dam constrains the impounded water. The upper section contains a small growth of sedges, grasses, pond lilies and other moisture loving plants. A representative view of this upper section is shown in Fig. A, Pl. 3. After passing through a tangle of water plants the water engages a wier in a low dam on its way to the lower section. The lower section is kept quite free of water plants and presents a much less unsightly appearance. About its margins ditches have been constructed, guarded on the water side by low ramparts of earth. These are intended to prevent drainage from the adjacent slopes finding acccess to the reservoir. They carry a great part of such drainage down to the foot of the reservoir, where it escapes into the natural stream. The upper section is not guarded in this manner.

Recommendations. The two aspects of chief interest in the above case is the effect of the rank vegetation at the upper section of the reservoir and the efficiency of the drainage precautions in the lower section.

It is well known that water from shallow lily-grown lakes or reservoirs is likely to produce temporary diarrhœa in most people, and in some cases this effect is permanent and prevents the use of such water. This effect seems to be most marked during the season when the plants are decaying. During the summer the surface water is warmest and, therefore, lightest, and as a result the low waters of the reservoir are stagnant, the transmission of water occurring along the surface only. But with a change to cooler weather the lower waters are warmer, the upper waters being cooled to the temperature of the cold air. Then the lower water rises, dark in color and foul in odor. These qualities result from the lack of air in the presence of decaying vegetation. There has been no circulation of the lower waters up to this time and in the presence of decomposing vegetable growth the little oxygen in the water has been consumed. At such seasons, therefore, it would seem that the injurious effects of the water would be at a maximum, and some more efficient means of circulation and aeration should be provided. This could readily be accomplished by arranging a short series of little dams and aprons, not unlike the steps of an ordinary stairway, on the lower side of

the dam, separating the two sections of the reservoir. A similar plan might be adopted at the lower end of the lower section just before the water is pumped into the village mains.

The growth of the plants in the upper reservoir could perhaps at the same time be decreased by a covering which would exclude the light. Ground waters are usually charged with mineral matter suitable for plant food, and unless light is excluded the higher organisms will be likely to thrive on it. For this reason the great reservoirs which supply the city of Paris are kept constantly dark with good results.[1] It would conduce toward the same result thoroughly to clean and deepen the upper reservoir, putting in a coarse gravel bottom and paving the shores a few feet below the level of the water. It is by these means that the city of Cambridge, Massachusetts, keeps its reservoirs free from vegetation. The additional precaution is adopted of cleaning away at intervals all grasses which have started between the blocks of paving. This method is cheaper than that of covering the reservoir with a roof and at the same time preserves the beneficial, while doing away with the harmful effects of sunlight.

Regarding the efficiency of the drainage arrangements in the lower section, it may be said that polluting substances are not excluded wholly at the surface. They may sink into the ground and moving with the ground water enter the reservoir. The watershed of the reservoir is well protected at Waterloo, except from barnyard dainage on one side. A barn is located at the top of the slope leading directly to the reservoir, and much of its drainage must sink into the ground as described. It would be highly desirable to have the site changed a little farther from the pond. A slight change to the southeast offers drainage directly into the natural stream and away from the reservoir.

Contamination through pond water. The use of stored water for boiler purposes in mills on the upland is worth further consideration by mill owners. The demands for purity are not so riged here, and unless the pond or reservoir is used as a dumping ground by residents, is not likely to lead to any injurious effects in nearby wells. One case in which bad effects were likely to follow was noted beyond the boundaries of the district to the south. On account of its character the exact location is not given. The reservoir was bordered by three privies, two of which connect directly with the water. One hundred and twenty feet from the southeast corner of the pond is a well, from which a family is supplied with drinking water. Careful leveling showed that the level of the water in the well was one foot eight inches below the level of the pond. It was stated by the owner that the level of the water, both in well and pond, fluctuated with the seasons, so that the relation of levels may be more favorable at other times in the year than when visited by the writer. If such is not the case, the condition is certainly a dangerous one, especially if the conditions become long standing.

Conclusion. The difficulty of securing a protected watershed in the well settled part of the State, included in the East St. Louis district,

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1 Mason, Water Supply, 1902, p. 276.

A. Upper reservoir of the Waterloo public water system.

B. Falling Spring, showing exit of underground stream at a point half way up the Mississippi bluffs; and improvements for the use of the water.

will always mean a very limited use of impounded water. The use of ground water recovered in shallow wells will be likely to supersede even such uses of stored water as now exist.

UNDERGROUND SOURCES OF WATER SUPPLY.

(BY ISAIAH BOWMAN.)

WATER RESOURCES OF THE MISSISSIPPI FLOOD PLAIN.

Special features of location. The natural position of the Mississippi flood plain with respect to the river which formed it and the importance of that river in commerce would tend under any circumstances to make its riparian population denser than the population elsewhere in the East St. Louis district. Combining with these physical circumstances is the location of the city of St. Louis across the river and the natural expansion, therefore, on the flood-plain. The economic stimuli noted on pages 4-6 produce the same effect. We thus have a keener interest manifested by the flood-plain population in the question of water resources than on the part of others; and the reader will consequently find this section of the report unusually detailed as to facts and full as to discussion.

In the matter of general interest the unique position of this district makes it one of the greatest importance. Above New Orleans no city, with the exception of Greenville, derives its supply from the flood-plain waters. The renowned Memphis water works system derives its supply from sources back of the upland bluff, as does Helena, Arkansas, and Vicksburg, Mississippi. St. Louis derives its supply wholly from the Mississippi river, as does East St. Louis. We have, then, a village or suburban population and manufacturing interests demanding here a greater supply than elsewhere on the whole flood plain of the Mississippi. The association of upland, flood plain and river are also in some respects unique at this point, as later pages will show, and inasmuch as no detailed study has heretofore been made at any point on the flood plain above Louisiana, the present report may be regarded as a pioneer in a new district.

UNDERGROUND DRAINAGE.

Direction of Movement.

A preceding discussion of the hydrographic features of the district has prepared the way for an understanding of the actual underground water conditions, as well as the several conflicting theories among local students of these conditions in the area under discussion regarding the source of the ground water and its direction of flow. Some have asserted that the source of the ground water is the Mississippi river; that the river is constantly losing volume by seepage through the porous sand and gravels which here form its eastern bank. Others maintain that the source is the flood water which, when the river is highest,

overflows the flood-plain and stands upon it for some time, undoubtedly sinking into the ground to some extent. Still a third class contend that the rainwater which sings into the upland seeps westward, and with the upland streams which lose their waters on the inner margin of the flood-plain constantly replenish the flood-plain waters to the extent of causing them to move westward to the river. In each case the explanation begins with a well ascertained fact, but it may be shown as a general proposition that any resultant is seldom caused by a single condition of fact, but by a combination of conditions, and that the evaluation of each in the general result must be carefully accomplished. Therefore, not only the initial fact, but the logic which makes use of the fact, and, in addition, still other facts must be scrutinized.

Level of the Water Table.

Relation to the Mississippi. We may dispose of the first contention by pointing out that during most of the year the ground water of the flood-plain stands at a higher level than the surface of the Mississippi. This means that the ground water is under an actual head or pressure, equivalent, except for a frictional compound, to the difference of level between its upper surface and the river. Since the flood-plain deposits are for the most part porous, the ground-water cannot remain stationary under this head, but in response to gravity moves down the slope of the water table towards the river. In other words, the ground water is positively feeding the river most of the year and not being fed by the river.

This condition is well shown in Figure 8, which is based on a drawing by Assistant City Engineer P. B. Leivy, of East St. Louis, through whose courtesy the original drawings were obtained by this survey. The figure represents a section in East St. Louis practically at right angles to the river and hence unusually valuable in this connection. The upper line in the section expresses the character of the surface, and the position of the water table (the surface of the ground water) during the winter of 1904-1905, is shown by the middle line. The section chosen was from 31st street, westward to the river below the mouth of Cahokia creek and combines features shown in part of sections A, C and D of the sewage system of East St. Louis. It shows a decrease from 94 to 67 feet (datum being zero of the St. Louis gauge), or a gradient of 10 feet per mile. The importance of these figures may be appreciated from the fact that the distance across the flood-plain at this point is only slightly greater than twice the length of the above section. Therefore, the water of the whole flood-plain must be moving toward and not from the river.

This general statement must, of course, be modified to the extent that high level creeks supported by levees and drainage across the flood-plain, feed by leakage the ground water in their vicinity. The profiles here show. as for example, along Cahokia creek, a movement toward the flood-plain at right angles to the channel, but only so far as the head of the creek water exceeds the head of the ground water. Beyond this point water again turns into its general course toward the river.

This general condition does not hold true, however, during a period of high water when the river is rising against the outer side of the restraining levees, and stands higher than the surface of the ground water. Although this condition is, relatively speaking, exceptional and

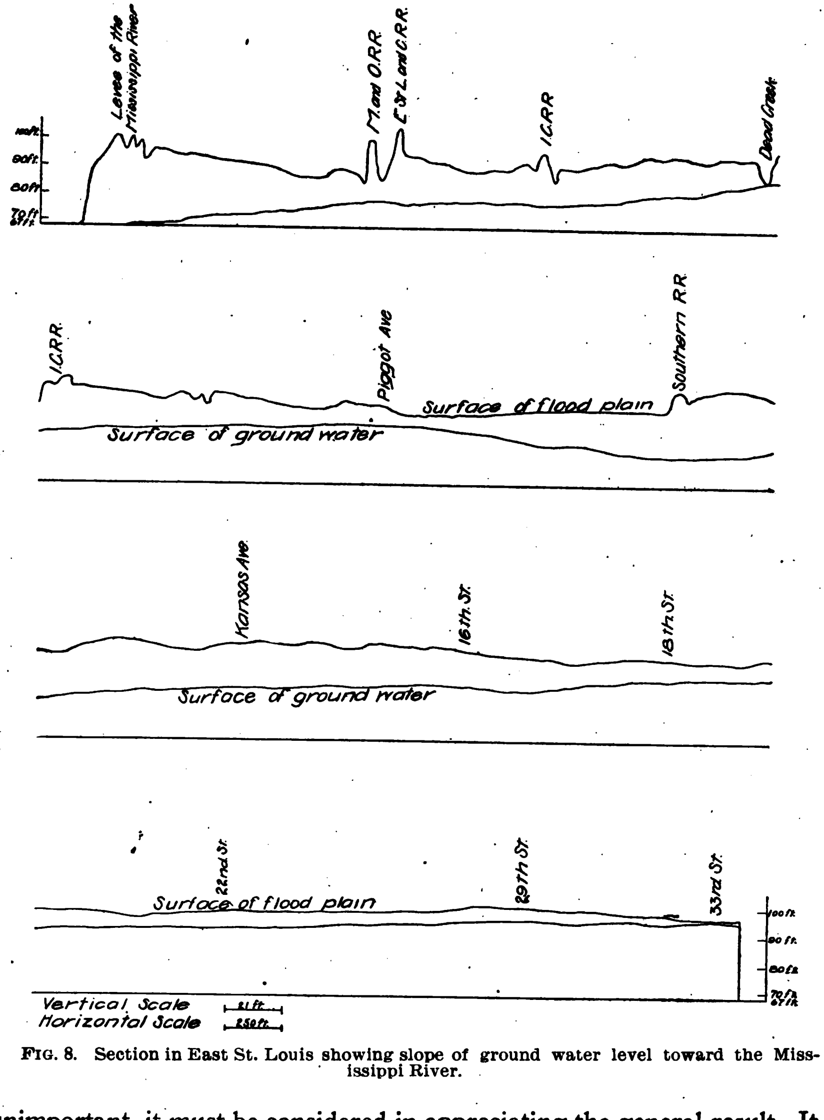

FIG. 8. Section in East St. Louis showing slope of ground water level toward the Mississippi River.

unimportant, it must be considered in appreciating the general result. It is the popular conception that at such periods of high water the "backflow" as it is commonly called or the seepage from river to flood-plain fills these deposits to the degree to which they were depleted during the preceding year. That such a rate of seepage is impossible is shown by

the results obtained by Professor Slichter and noted in "The Motions of Underground Waters,"[1] and by his experiments on the rate of underflow of the ground water on Long Island in 1903[2]. In the latter case the rate of movement was from about two to ten feet per day, under normal conditions. As the loose textured glacial material of the Long Island outwash plain may fairly be assumed to be much coarser than any of the flood-plain deposits in this district, the rate of underflow must be here much smaller. But even assuming the maximum rate of ten feet per day, we should have the water moving but six hundred feet in two months. True, the relative head in the short distance between the bank of the river and the inner side of the levee is probably several times greater than the head of the ground water in equal distances in the outwash plain of Long Island. Allowing for this, in a rough way, and considering the length of the flood period as one month, we would probably have a result still decidedly short of 1,000 feet, or less than one-fifth of a mile. The assumption of a month for the duration of the flood period is based on the hydrographs of the river published by the Mississippi River Commission.[3]

We may conclude from this line of reasoning that as far as a continuous supply is concerned, lateral seepage through or below levees is not an important factor in replenishing the ground water of the flood-plain.

Effect of inundations. If the flood-plain is actually covered with water during a flood season, the rate of increase in the amount of ground water is of course much greater than in the case just discussed. The area of contact between water and imbibing earth is vastly increased the seepage is vertically downward and not lateral. The whole earth becomes saturated from the normal level of the water table to the surface and the surface of the standing water may then be taken as the temporary representative of the upper surface of the ground water. The moment the swollen stream contracts the accumulated waters over the flood-plain subside and soon the ground water and river are in process of establishment. It is difficult to make a statement of quantitative values in this connection. One may say in a general way that the opportunity for rapid evaporation is good where the ground water directly after flood stands near the surface or is exposed in swollen bayous and that the run-off into tributary creeks must at first be rapid. From the measured rate of discharge of these tributary creeks it would appear that their normal regime is resumed as soon as in the case of the Mississippi and this may, therefore, afford us a rough measurement of the time required for flood water effect to disappear.

The period which this effect covers and the relative infrequency of complete submergence of the flood-plain would argue that even the flooding of wide areas is not to be regarded as of importance. The essential and characteristic features of the ground water would seem to be found in some other relation in which conditions attain a balance that is only now and then interrupted by flood.

(1) Water Sup. and Irr. Paper, No. 67, U. S. Geol. Surv., 1902.
(2) Prof. Paper, No. 44, U. S. Geol. Surv., 1906, pp. 89-116.
(3) Annual Reports, Mississippi River Commission, 1904 and 1905.

Effect of rainfall. The key to the normal condition of the ground water is the rainfall upon the flood-plain itself and the supply from the upland.

Regarding the first point it may be said that the mean annual rainfall is about 38 inches per year. The surface of the flood-plain is so flat that the rate of run-off is exceedingly low. A large part of the rainfall sinks into the ground, perhaps in excess of 50 per cent; which means roughly, half a million gallons yearly per acre, or 300,000,000 gallons yearly per square mile, or, on the average, 1,000.000 gallons per square mile daily. This amount, falling at intervals through the whole year, is a much more important factor in maintaining the ground water than the flood waters which temporarily overspread the flood-plain and rapidly subside. In the case of rainfall a maximum absorption value is attained by reson of the flatness of the surface and the normal dryness of the ground, while in the case of flood any excess of water, after the complete saturation of the surface material, runs off and does not accumulate as available water for later drier periods.

Accretions from the upland ground water. The constant addition of large quantities of water to the eastern margin of the flood-plain by streams has already been noted. This not only raises the level of the ground water along the margin, relative to the surface, but its absolute level is also raised on account of the absolute altitude of this part of the flood-plain (See map, plate 4.) Well No. 29 at an altiude of 420 feet has water 15 feet below the surface. That is, the altitude of the ground water is 405 feet, while the surface of Horseshoe Lake. 2½ miles southwest, is 402 feet. Compare also the heads of the water in wells No. 26 and 27 (Fig. 9.) In the same way that the rains falling at intervals

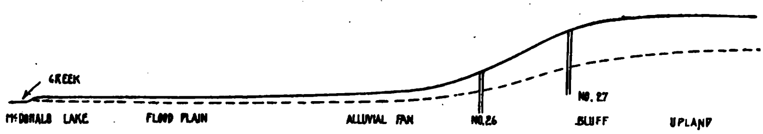

FIG. 9. Profile across upland bluffs one mile south of Peters, showing surface of ground water in relation to topography.

through the year play a much more important role than flood waters, so the constant addition of water to the eastern margin of the flood-plain must be regarded as of more importance than the transient accumulations which appear at times of flood. Irregularities in the flood-plain surface affect the level of the ground water to the extent of altering the above relation in some cases, but the general movement of the ground water toward the river may be regarded as well established.

If the relation between the amount of water supplied by rain and by streams from the upland were known, undoubtedly it could be shown to what extent the normal deformation of the water table in response to topographic irregularities is overcome by the inflow of upland water. The well records in the area are too widely scattered, however, to permit of any such conclusion.

The two wells, Nos. 26 and 27, shown in figure 9, one mile south of Peters, are very instructive in this connection. They are located but 250 feet apart on opposite sides of the bluff road. The westernmost one is at the top of the waste slope which here forms the margin of the lowland, while the other is 30 feet higher, part way up the slope of the upland bluff. The water level is 30 feet in the upper well and 8 feet in the lower. The surface of the ground water at this place and its realtion to the topography are expressed in figure 9. This condition may be taken as representative of the conditions elsewhere along the bluff.

The water level in wells located on or near the valley bottoms of upland streams at the point of debouchure at the upland bluff reflect the periodicity of the water level in those intermittent sreams. Well No. 22 may be taken as typical. In time of high water in the stream, water may be dipped out of the well mouth by hand, while in the dry summer season when there is no surface stream the well contains no water at all, the valley underflow being apparently at a depth in excess of the well bottom (16 feet.) All the wells at Peters which are located on the flood-plain near Judy's branch show similar control. They vary in depth from 15 to 50 feet, according to their precise location.

In the process of valley widening, detached or partially detached portions of the upland appear occasionally in close proximity to the upland bluff. Many examples may be noted on plate 4. One such occurrence is at Peters just north of the tracks of the Litchfield division of the Chicago, Peoria & St. Louis Railroad, indicated as well No. 23. In contrast to the other wells in the vicinity, it is 100 feet deep, the head of the water in it being 95 feet. The well is on the top of the hill and as surface drainage is excellent in all directions, the groundwater is far below the surface. Well No. 24, but a short distance away, at about the same elevation, is on the upland bluff and receives a plentiful supply of water from 30 feet below the surface. It receives drainage from the upland and so has a higher water level, although its relation to the run-off in its vicinity is similar to that in well No. 23.

CONCLUSION.

We may conclude from the foregoing that the normal condition of the ground water in the flood-plain is maintained by rainfall and tributary upland drainage which produce a general movement of the water toward the Mississippi, this general movement being modified here and there by slight topographic variations. The flood water contribution is insignificant except in cases of actual overflow, and even in the latter case the effect is temporary.

OCCURRENCE AND RECOVERY OF THE GROUND WATER.

Having considered the surface and underground drainage of the flood-plain and noted its source. movement and disposition, we shall now be able to consider the vertical distribution and the availability of the flood-plain deposits.

Occurrence. . .The matter of first importance in this connection is the structure of the deposits, as represented in figure 4. It was there noted that the chief characteristic of these deposits is their irregularity. The conditions of deposition were of such extreme irregularity that practically no continuity in gravel or sand beds of a given texture is determinable. The shifting bed of the stream, the phenomenon of cut-offs, the irregularities due to overflow, all these combine to produce deposits of extreme variability, both vertically and horizontally.

Shallow wells (Nos. 43, 49, 113) indicate that the water level occurs normally from a few inches to a few feet below the surface, the precise depth being dependent on the precise elevation of the well head and the conditions of surface drainage. Such wells are never drawn on heavily and consequently need not be immediately replenished after the withdrawal of water. Were the requirements greater, these wells would be pumped dry very quickly for the water is supplied from fine sands through which it must flow with extreme slowness.

If a constant draft must be maintained, a well must strike what the driller calls a vein, that is to say, a bed of coarse sand or even gravel through which water makes its way quickly to the well bottom in response to the head under which it occurs at that depth. One may inquire whether, if the gravel is supplied from above, the supply would not soon be temporarily exhausted on account of slow delivery through the overlying sands. This is not true because in the former case delivery through the fine sands was made only at the well wall bottom, while the delivery to the gravel in the latter case is over the whole surface of the gravel, and the more vigorous the pumping, the greater the area of this contributing surface.

Recovery. The wells in the flood-plain deposits vary in depth from 10 to 170 feet. Since a greater supply can be had by sinking the wells to a depth of 40 feet than 10 feet, most individuals do this, the additional expense not being great. Where factories have put down wells they have usually gone deeper, since they need a larger supply than for household use. The factories have sunk wells 40, 60, 90, 110, 120, 170 and in a few cases 360, 400, 1,500 and 2,900 feet. These latter ones, however, reach beyond the depth of the flood plain deposits and are considered under "Water Resources of Deeper Horizons."

The old way of putting down wells on the flood-plain was to dig them with a shovel or spade and put down curbing, usually of boards, to prevent the sand from caving in. The water was then drawn by a pulley, bucket and rope. Many of the old wells are of this type.

A simpler, more economical and healthful way of putting them down is now in use. For household use a sand point attached to the end of successive joints of 1¼-inch or 2-inch pipe is driven down through the gumbo, clay, sand, etc., until a water-bearing horizon with abundance of water is found. Then a pump it attached to the last joint of a series of pipes which are usually four feet in length and the water drawn up through the screen, at the well point, to the surface. Wells of this description usually afford plenty of water for the household and for stock and are not expensive.

For factories and other purposes larger sized casings are used, varying from 3 inches to 12 inches in diameter. The casing is forced down and the sand on the inside removed by sand pumps. When the desired amount of water is found, a strainer usually of the Cook type is lowered inside the casing to the bottom of the well. Then the casing is pulled up until the lower end reaches the top of the strainer, where the two ends join. The well is now complete except for the pumping apparatus which is installed later, thus leaving the strainer in contact with the water-bearing sand.

CONCLUSION.

On the whole, it is seen, both from the preceding observations and the tables of analyses and sections which follow that, although the waters of the Mississippi flood-plain may be recovered without great difficulty from lenses of coarser material in the generally fine deposit, the water when so recovered is undesirable for boiler purposes on account of the scale which forms from its use. This condition can be remedied by chemical treatment and thorough filtration, but the well owners have generally regarded the erection of a plant for this purpose too expensive. Consequently, most of them are using city water. A few are earnestly endeavoring to devise means for the proper purification of the well water. On the whole, this seems to be the best line of advance in view of the increased mineral content of the deeper water. The erection of small filter plants similar to those now used by the City Water Company would seem to be the most advisable plan for those located near the larger tributaries of the Mississippi.

WATER RESOURCES OF THE KARST.

Under this heading will be discussed the water conditions and resources of southwestern part of the East St. Louis district which lies south of Stolle and between the upland bluff and Hickman's creek, plate 4.

Difference between ground water and karst water in relation to successful wells. As pointed out by Penck[1], the terms ground water and karst water are not synonomous, and the laws which apply to the former cannot be applied to the latter in attempting to serve the practical interests of prospective well owners. If a well is sunk into sand or gravel, an adequate supply for domestic uses is usually obtained under ordinary conditions by placing the bottom of the well a few feet below the top level of the surface zone of saturation. Such a surface zone of saturation is also present in limestone in which the phenomena of the karst are developed and may be reached in the same way with the same assurance of success. But in the former case the water absorbed after rainfall sinks as a broad sheet vertically downward through the interstices of the sand or gravel and does not become available water until it reaches the surface of the ground water. This may

(1) Op. cit., p. 13.

be appreciated from the fact that a well whose bottom lies below the surface of the ground water will, if steadily pumped, be replenished by the lateral movement of the water at the surface of the ground water. This lateral movement is merely an expression of the uniform tendency of water to assume a level upper surface, the tendency being in this case displayed as a local coniform depression of the water table, down whose sides the water is forced to move. The direction of movement of water sinking through pervious material is on the other hand not lateral, but nearly vertically downward. The lateral component of motion, which is the motion required to bring water to the wells, is present to a slight degree only and a well sunk to any depth short of the surface of the ground water will, therefore, receive the more trifling supplies at intervals almost as irregular as the intervals of rainfall at the surface.

The conditions are radically different in a karsted region. The presence here sink holes, funnels, rifts, underground passages, etc., and the part they play in the removal of water, has already been noted. Rainwater falling upon the surface quickly flows down the steep slopes of sinks and from the beginning of its journey to its reappearance in lake or spring or river is in motion in a definite channel. It is this feature of definite underground drainage in limestone regions, which, perhaps more than any other, has led to the popular notion that all ground water flows in this manner. This notion is, however, erroneous.

Seepage plays a far less important role in karsted limestone than under normal conditions, for the water is conducted underground not mainly through the tiny pores of the surface material by definite channels and openings and once underground the movement is continued by passages and channels quite as well marked. In the young and vigorous stages of karsting under ordinary conditions the proportion of water which finds its way underground by seepage must be very small as the hard rock would favor an increased run-off, but in a thick deposit of loess which is very porous and undoubtedly absorbs more rainwater than would hard limestone, a portion of the rainfall is absorbed to be delivered to the ground water by seepage. One is tempted to speculate on the degree of aridity which would be displayed here without the covering of loess. Under present conditions the droughts of summer are often severe and with better facilities for the quick removal of water, the degree of aridity would probably be pronounced.

Uncertainty of supplies in karsted region. One of the first consequences of the occurrence of water in joints, caves, underground channels, etc., is the decided uncertainty of obtaining shallow supplies. The rapid run-off afforded by these channels favors a much lower stand of the ground water than in normal cases so that deeper wells are required in the karst for corresponding advantages. But shallow dug wells are cheaper and oftentimes the only resource of the farmer, consequently the occurrence of the karst water or the water that occurs in channels, etc., as distinguished from ground water, is of the greatest concern.

The element of uncertainty is illustrated by a well located near Burksville Station, south of the southern limit of the area shown in the map (plate 4). The well was first drilled to a depth of 160 fee through

sandstone and limestone and no water whatever procured. The breaking of the drill at 160 feet caused the hole to be abandoned and a well four feet in diameter was dug in the same spot to 35 feet, or five feet below the surface of the sandstone which here underlies the loess. Seepage water which collects on the surface of the sandstone supplies the well and is of good quality. To prevent the loss of the water through the drill hole, the latter was plugged. The limestone in which the greater part of the 160-foot hole was drilled is extensively karsted about Burksville, the Eckert cave being located 1½ miles southwest of the railroad station. The sandstone which occurs above the limestone produces the condition of the perched ground water table analogous to the condition on Long Island, described by Veatch[1]. All about the well in question, where the sandstone does not occur, wells are of greatly varying depths and are sometimes entirely unsuccessful.

A still better illustration of the uncertainty attending well construction is supplied by No. 106. one mile south of Stolle. This well is 250 to 300 feet from a sink hole in which water stands the year around, and at an elevation 25 feet above the surface of the water in the sink. Yet a well sunk to a depth of 60 to 70 feet was wholly without water. This feature, as well as that of adjacent sinks with greatly varying water levels, illustrates the frequent entire independence of passages leading underground. In rock thoroughly jointed, this would, of course, be impossible below the level of the loess and to a limited extent only above that level.

In general, it may be said that no means exist for the determination of successful sites for shallow wells. Repeated trials over an area an acre or two in extent are sometimes unsuccessful, while in other localities a second trial is quite as often successful. In the region shown in plate 4, south of Stolle, the depths of the wells range from 45 feet to over 100, and the water level in short distances at equal elevations has a range of at least 30 feet. Some wells in favorable localities are supplied by seepage, others from underground streams or pools. In the latter case, the well is usually completed in a small underground cavern. The cavern feaure is often recognized in drilling a well here and not infrequenty leads to the loss or breakage of the drilling tools.

SPRINGS OF KARSTED REGION.

The reappearance of karst water at the surface is usually in the form of springs or streams. Thus at Stolle (No. 108) a spring issues from the bottom of the Caspar Stone Quarry and Contracting Company's quarry. It delivers a 4-inch stream which is used for boiler purposes. A second stream of smaller side issues from a crevice on the walls of the quarry.

FALLING SPRING.

Location and relations. The most remarkable and important case of this kind in the district occurs at Falling Spring on the upland bluff

(1) A. C. Veatch and others. Underground Water Resources of Long Island, New York. Prof. Paper No. 44, U. S. Geol. Surv., 1906, p. 57.

over a mile south of Stolle. A large stream, equivalent to the flow from a 12 or 15-inch pipe, under a low head, springs midway from a cliff 150 feet high, and falling, maintains a small tributary of Prairie du Pont creek. This is the opening or mouth of an underground passage which has been penetrated by explorers for several hundred yards. The course may be followed quite easily by stooping slightly. The stream is supplied from the numerous sinks which occur in the upland immediately back of the bluff at this point, and from the linear arrangement and close succession of the sinks at first due south and then slightly southwest of Falling Spring, it is probable that the stream is supplied by these sinks which mark the course of the underground passage. This relation between sinks and underground courses has been noted by several writers[1].

Improvements. Falling Spring has been improved as shown in figure B, plate 3, two troughs conducting a part of the stream to tanks which supply with water the railroad engines that pass on their way to or from the quarry. The upper tank supplies a nearby quarry and also a fountain a few yards back of the observer in the picture. Further improvements are projected—looking toward the utilization of the water for bottling purposes, etc. The spring is one of great natural beauty in its setting of white limestone and bright green foliage and will undoubtedly in the near future lead to park and garden improvements for the attraction of the Sunday visitor from St. Louis and other nearby towns.

Turbidity of water after rain. A direct result of the covering of loess which easily eroded and transported down the sides of the sink holes into underground passages, is the muddiness of all karst water in this district after rains. In exploring Eckert's cave, near Burksville, the writer, with Professor Fenneman, noted the presence of large heaps of loess dumped here and there at the mouths of underground streams tributary to the principal one. In transporting this material large amounts are carried in suspension and thus the quality of the water is seriously impaired. A sample taken from Falling Spring on June 25, 1906, by this survey, directly after a two or three-day period of rain, was analyzed by the State Water Survey and yielded on evaporation a total residue of 825 milligrams per 1,000 cubic centimeters. This consisted chiefly of loess which gave the water a yellow color not unlike the color of Mississsippi river water, a very decided turbidity and an earthy odor.

Travertine deposits at exit. The accumulation of the loess about the exit of the spring together with the precipiation of the dissolved calcium carbonate results in the formation of great semi-pendulous masses of travertine ,a muddy yellow in color and very friable and light in weight. The deposit is distinctly layered. Extensive deposits of this material a few yards on either side of the present opening show the changes in the position of the spring which have taken place under the influence of the irregular retreat of the limestone cliff. At various points in this vicinity and at about the level of Falling Spring many

(1) Penck, Op. cit., p. 25, and others.

little streams issue in a similar manner and have associated with them similar deposits of travertine. Occasionally one may see such deposits at the mouths of little cavernous passages a few inches in height and extending back from the cliff face. The passages are often no longer occupied by water even after rains and are, therefore, indicative of stream adjustments within the limestone whereby streams have been diverted from courses long maintained. It is not unlikely that such adjustment may occur in the future history of Falling Spring and in such manner that a lower and less useful as well as less picturesque outlet will be formed. The issuance of the spring at a reasonably high level will always be assured, however, from the fact that the level of the ground water is not far below the present level of the exit.

Varying quality of water. Several weeks after a rainy period the water of Falling Spring presents a very clear and sparkling appearance in contrast to its previous muddiness. A sample taken on July 23d showed a decrease in the residue on evaporation to 398 milligrams per 1,000 cubic centimeters, and an entire absence of any earthy smell. A very surprising change in the general character of the water is also noted. The sample collected directly after a rain showed an alkalinity of 83 parts per 1,000,000, while that collected during a dry period showed an alklinity of 328. Obviously, an increase in the volume and velocity of the karst water will reduce the opportunity for contact with the limestone and correspondingly the amount of alkaline matter taken in solution; and as the solvent acton of water is further reduced by an increase in the amount of earthy matter carried in solution this decrease during rains will be still further emphasized. Other changes of a chemical naure are noted in the table of analyses. These are as interesting, but not as important as the ones just considered.

WELLS IN KARSTED REGIONS.

Turbidity of well water in the karst. The turbidity of water in wells which reach the karst water is also observed after rains and is a nuisance to well owners. The causes are identical with those noted above and so far as one can see, the condition is not preventable. In some cases the well owner has thrown salt into the well in order to precipitate the loess, but this is quickly removed by the moving water if the well bottom is in an underground stream, and if the well bottom is in a pool, the saltness of the water renders it no less unpalatable than the loess. The well owner is, therefore, obliged in some cases to build a cistern and store up rainwater as a resource when the well water is not palatable.

Contamination of karst water. A word of caution to well owners in the karst may well find a place at this point. Any of the common sources of contamination, such as cess-pools, cemeteries, etc., are by reason of the quick descent of surface waters to underlying sources rendered unusually effective and, therefore, unusually dangerous. A small cemetery now occupies a prominent place on the upland, only a quarter of a mile south of the springs in the Stolle quarry. It seems almost impossible that some of the drainage from this spot should not

find its way into these springs to the risk of the users of the water. That such is actually the case could of course be determined only by experiments similar to those conducted so often in the karst of the Austrian Adriatic provinces. These consist in throwing large amounts of aniline dyes into certain sink holes below which running waters are found and observing which ones of the springs round about are discolored. By this means the pattern of the underground drainage and the direction of movement of the waters are determined. In rural districts sources of contamination are not usually grave on account of lack of sufficient concentration of polluting material, but the growth of a large cemetery forms just such an unusual case of contamination and water supplies in the neighborhood are even under ordinary circumstances rendered doubtfully pure, and in a karst region are almost certain to be a source of polluion, and ulimately of epidemic. A surface stream that drained through a cemetery would under most circumstances rightly be regarded as unfit for use; even better opportunities for pollution are offered by sub-surface streams of the type here considered.

CONCLUSION.

As a whole, therefore, the karst waters of a limestone region are less safe, less constantly clear, and less available than are the waters of a region of normal sub-surface drainage. Even the ground water is less available than under ordinary conditions, and less safe on account of the quick descent of surface drainage which elsewhere seeps slowly down through porous materials and is, thereby, at least partly filtered of its impurities.

WATER RESOURCES OF DEEPER HORIZONS.

ARTESIAN CONDITIONS.

Unlike the surface sources of water supply and the ground water, the deeper horizons are to a large extent independent of surface drainage, since the direction of flow is determined by geologic rather than topographic features. By referring to the discussion of the geologic features of the district it will be seen that the rocks are composed of sandstone, shales and limestones and that they dip from the west to the east, producing artesian conditions. This is shown graphically in figures 2 and 3. Where the outcrop of the water-bearing strata is as high or higher than the top of the well the water flows out on the surface, producing a flowing well. In case the outcrop does not reach so high, the column of water rises in the well to a point where it equalizes the pressure in the water-bearing stratum. This is an artesian well, but it is distinguished from a flowing well by calling it a non-flowing well.

Flowing wells. The flowing wells within the district tap the lower geological formations since it is only here that the water is found under sufficient head to rise to the surface. The flowing wells are located as follows: Mascoutah, 3,069 feet; Granite City, 2,590 feet; Peters, 1,506 feet; Edgemont, 782 feet; Alton, 1,400 feet; Monk's Mound, 1,552 and 2,100 feet.

Non-flowing wells. The non-flowing wells seldom reach below 700 feet. The line of demarkation, however, between the flowing and non-flowing wells is not constant, since the artesian conditions are dependent upon the geological structure which varies locally, as well as in its general dip from west to east. Most of the wells of this class reach down to the sandstone member at the base of the coal measures. The wells at Belleville are representative wells of this type.

Catchment area. The catchment area for the flowing wells is beyond the Mississippi river along the flanks of the Ozark mountains. While that of the larger part of the non-flowing wells occurs in the western part of the district, the catchment area for the Belleville wells which is the largest region of the non-flowing wells occurs only 10 or 12 miles west of the city of Belleville.

Quality. Unfortunately the water in the deep wells below 515 feet on the upland, and 370-420 feet on the flood-plain, are brackish and unfit for factory, city or private use. In some cases as at Mascoutah, a good quality of water was found below this depth, and the salt water cased off, but in the course of 4 or 5 years the salt ate through the casing and came up with the pure water. The water found in the St. Peters sandstone is brackish in all cases when reached in this area, consequently in future drilling for deep city or factory supply, it will be unprofitable to go below the first salt water horizon.

Deep Artesian Waters as a Source of Pollution.

General statement. One of the points of chief concern in the penetration of deep-lying strata that are water-bearing is the possibility of pollution of sweet water near the surface by infiltration of mineralized water from a greater depth.

Illustrations of unfavorable conditions. The conditions leading to such pollution may best be understood from an examination of several specific cases of deep wells of this kind.

(1) Well No. 45, belonging to the Niedringhaus Steel Mills Company of East St. Louis, is 2,590 feet deep. The surface of the ground at the well is 94 feet above datum of Granite City, which is 313.84 feet above sea level. The water has been piped to an elevation of 54 feet above the surface where it overflows in a full 8-inch stream. The pressure exerted by the artesian water at the surface is very great, 45 pounds per square inch. This means that the head is approximately 100 feet above the surface. On emerging from the pipe the water is quite clear and sparkling, but soon becomes dark in color and leaves a black and a yellow deposit on everything with which it comes in contact. It is strongly charged with mineral substances, as the partial analysis quoted later shows.

(2) Well No. 28, belonging to Ferdinand Keller, is located two miles south of Peters. It 1,506 feet deep. It yields a strong stream of salt water and a small quantity of oil at the present time which runs off at the surface into a nearby creek. The well was drilled for oil, but salt water came in so strongly as to prevent the making of tight joint between casing and rock, and after several attempts the well was left to yield practically nothing but salt water as at present.

(3) Well No. 193. When the deep well was sunk at Mascoutah, Illinois, salt water was encountered at 6,239 feet. It was cased off and the well sunk to 3,069 feet. The water obtained at the lower level was sweet and came to the surface through the lower uncased bore hole and a 3-inch pipe which reached down to 1,500 feet. In four to five years, however, the salt water at 3,069 level has eaten through the 3-inch casing and the sweet and salt water now mingle and flow out at the top. For the chemical analysis of the water before the salty and sweet water flowed together see page 76.

Relations of different water horizons. In all the above cases it will be noticed that the head of the deep-lying water is far greater than that of the upper waters. In fact, in the majority of cases no flows exist except from the deeper horizons, the head of the water increasing with depth below the surface.

The possibility of pollution by the escape of this undesirable water into the upper horizons is commonly known in oil regions where the most stringent laws exist as to the care of wells, either actually in operation or abandoned. The care, it is true, is exercised not from the standpoint of preserval of drinking water, but from the standpoint of the maintenance of oil and gas fields.

The matter of contamination from this source has been fully discussed in a Water Supply and Irrigation* paper on "Well Drilling Methods: Their Geological and Engineering Aspects," by the present writer, and the following discussion is adapted from that report.

Defective casing. In the case of water wells, which, as a class, are of much wider distribution than either oil or gas wells, the same care in packing, plugging and casing wells is not exercised, though the results are sometimes as pernicious as in the preceding cases, if not of as great economic importance. In many states, as, for example. Michigan, Wisconsin, Washington, etc., it has been made unlawful for a well owner to allow water from an artesian well to escape in needless amounts through the opening in the pipe near the surface. Oftentimes, however, it can be shown that even where such precautions are taken large amounts of water are being lost continually through defective casing. If iron piping is put into the ground in the form of a sewer, it would not be expected to last more than perhaps ten or fifteen years at the longest, but if it is put into the earth in the form of well-casing, there is usually no consideration of its longevity. It is tacitly assumed to last forever, while observation on casing withdrawn after having been in the earth both short and long periods, shows conclusively that it suffers deterioration and decay, and should be examined at short intervals for resulting defects.

Longevity of casing. The rate of decay of casing will depend entirely upon the conditions as they exist in individual cases. Casing withdrawn from wells 15 to 20 years old has been found to be in reasonably good condition except at the joints, though the usual experience is that casing of this age is too badly decomposed to be withdrawn at all. except in sections, and even this is not always possible.

If the waters which come into contact with the casing are heavily charged with minerals their reaction on the pipe usually results in their

*U. S. Geological Survey.

more rapid decay. In one locality, Dallas, Texas, the writer observed holes the size of a penny in casing which had been withdrawn after having been in the earth but *one* year. The strong mineral waters in one of the formations of that state, the Glen Rose, had damaged the casing so that it was little better than a sieve in a round hole.

State laws regarding the problem. The only way by which water supply interests could be protected in the event of the above conditions obtaining would be by making a thorough examination of the well hole and exploration of the amount and quality of water contributing to the yield of the well. This would be very greatly facilitated by having at hand a log of the well, that is, a record of the character and extent of each of the formations through which the bore hole had been drilled. This has been recognized by one state at least, South Dakota, in the following statute:

"It is hereby made the duty of the township board to embody in the contract for the sinking of said public artesian well a proviso that the person sinking said wells shall make a record of the depth of each well and the formation entered or passed through in the construction of the same, and such provision is hereby made an essence of the contract and a violation thereof shall be construed to be a violation of the contract." (L., 1891, chap. 80, sec. 35.)

It is interesting to note that this same state also requires that every person sinking an artesian well "provide for such well a proper casing, in order to prevent the well from caving in, and to prevent the escape of the water when it is desirable that such water be confined."

It is not clear, however, under the terms of the law, precisely what is meant by a proper casing, inasmuch as through the decay of the casing it may fulfill its function of confining strata or water for several months only, while, again, it may last over a period of years. It is not possibel at this time to take up in greater detail the means by which the bore hole in various conditions may be explored. It is sufficient here to state that such exploration can in every case be accomplished along scientific lines, and that more and more is actually being done.

SPECIFIC ILLUSTRATION OF POLLUTION.

Two specific illustrations of some of the above mentioned conditions have been supplied to the writer by Mr. J. E. Bacon, and are a result of experiments conducted by him looking toward the improvement of the water supply in the cities of Saginaw, Michigan, and Dallas, Texas. Mr. Bacon's kind assistance in putting this data at the disposal of the writer are hereby gratefully acknowledged.

Saginaw, Michigan. At Saginaw, Michigan, are located a large number of salt wells, many of which have been abandoned for one cause or another. In the case of the abandoned wells the bore hole allows salt or brackish water to reach the surface under the influence of the natural head of the water together with convection currents and diffusion. A part of the city supply had, previous to 1902, been drawn from a deep well system consisting of about 20 bored wells, having an internal diameter of 4 inches and a depth ranging from 89 to 230 feet. Most of these wells are in the bed rock and draw their supply from

sources which have been contaminated by the infiltration of brine from the salt wells. Up to the time that Mr. Bacon began his investigations almost no attention had been paid at Saginaw to the protection of surface water from contamination of this kind. The seriousness of the situation may be appreciated from the fact that possible sources of ground water supply at Saginaw are limited to the loose sands and gravels which overlie the rock and the top of the rock itself. Manifestly, the only way in which this water can be conserved in its original purity is by plugging abandoned salt wells at a suitable distance below the surface, and exercising great care in mainaining the casing in others intact. The condition has been partly remedied by the above means and water obtained for municipal purposes from the glacial sands and gravels overlying the sandstone.

Dallas, Texas. The second case is the one illustrated by condition at Dallas, Texas, where Mr. Bacon, in January, 1906, investigated the source and yield of potable waters for city use. Water is yielded by four formations which are named in the order of their occurrence downward, the Woodbine, the Paluxey, the Glen Rose and the Trinity. While these are locally separated as indicated here, the Glen Rose is really a part of the Trinity division.* The lower Trinity sands have never been explored in the Dallas region and their value as water producers, therefore, is unknown; but both the Paluxey and Woodbine formations contain sweet water. Most of the city wells derive water at the present time from the Woodbine and it is the inadequacy of supply from these sands which has led to the present investigation.

The peculiar conditions which are to be recognized here are those arising from the fact that one of the city wells penetrates the Glen Rose formation; and the water supplied from these sands is under greater head than that from the overlying Paluxey. Moreover, the Glen Rose water is strongly mineral. Its exact composition has not been determined for this locality, but west of Austin† the upper Glen Rose beds contain strontium, magnesium and sodium. Many residents of Dallas use the water for its real or supposed medicinal value.

This mineral water strongly attacks the well casing so that casing which had been in the well but one year was so seriously damaged as to exhibit breaks and checks in great number, and several of these were observed to be the size of a penny. The threads at the joints were completely decayed and unserviceable so that when an attempt was made to pull the casing each length was lifted out as it had no connection wih the next lower length. Its value, therefore, as a tight casing was practically zero. Add to this the fact that the Glen Rose water is under greater head than the Paluxey and it is seen that gradually the Paluxey sands were becoming impregnated with the mineral substances in the Glen Rose water. While the water is used for medicinal purposes by a number of the citizens of Dallas, it is unpalatable as city water and attempts to use it as such have proved unsuccessful. Its temperature is high and the contained salts give it a most unpleasant taste.

*R. T Hill, U. S. Geol. Surv., 18th annual report, 1896-97, part II, p. 279.
†Hill, Ibid, p. 300.

By inserting a packer, with piping, to the surface, between the Glen Rose and Paluxey sands, the two waters were separated, the mineral water with high temperature coming up inside the pipe, and the Paluxey between the pipe so inserted and the well casing. Differences in head and quality and temperature of water were at once noticeable, although the Paluxey waters were to some degree mineralized, this degree steadily decreasing as the experiment continued.

RECOMMENDATIONS.

These two examples with the preceding general discussion are sufficient to show the vital character of the problems which they involve and ought to lead to the following definite results:

1. An accurate log should be kept of every well drilled.
2. Every water-bearing formation should be carefully examined as to its thickness and the quality of the water yielded.
3. The head of each separate water should be accurately determined and its relation established with respect to other waters encountered.
4. The casing should be intact when the well is completed and should be kept so, its condition being determined from time to time by suitable experiments.
5. A change in the head or quality of the water should be interpreted only when the possible effects of defective casing are taken into account.
6. In those states in which the geological conditions are known to be such as to favor contamination through the operation of one or the other of the causes noted herein, laws should be framed making the examination of the well casing and the determination of the exact relations of separate water-bearing strata the duty of each well owner or well driller.*

THE LOESS AND DRIFT WATERS.

Source. All the water found in the loess and drift is ultimately derived from rainfall. When the rain falls upon the surface of the loess part of it runs off and part sinks into it. In both cases a portion of it is returned to the atmosphere by evaporation. The water which drains from the surface is called run off and is described on later pages.

The water which sinks into the ground through the interstices of the loess and drift and furnishes the supply for springs and wells, and in some cases for ponds and lakes, is called the ground water. At first this water moves vertically downward for a few feet until it reaches a zone where the material is saturated. The upper surface of this saturated zone is called the ground water table. In rainy or wet seasons it is found nearer the surface than in rainless or dry seasons.

Disposition in response to structure. The geological arrangement of the material is such that the more porous loess occurs on top and the compact till below, with an occasional thin bed of sand intercalated. The loess absorbs water readily and transmits it downward until it

* In view of the development of coal deposits in the East St. Louis district there would seem to be a further reason why casing should be maintained intact or the well plugged. The deeper waters under great head, if ever allowed to enter the Coal Measures, would do incalculable damage, not only by actually flooding the mines but by saturating the strata so as to yield water long after the mines have been pumped dry. The state of Pennsylvania has enacted stringent laws providing specifically for the avoidance of this sort of a calamity, inasmuch as the deep wells of the state are frequently in the same districts as the coal mines and accidents of the above description were formerly not of uncommon occurrence.

reaches the ground water table, which in some cases is the lower part of the loess and in others a lentil of sand, while in still others the top of the till. The geological arrangement of the porous loess near the bluffs facilitates the passage of the upland ground waters in seeking a lower water table on the flood-plain below. Throughout the upland the loess ranges from 50 feet along the brow of the bluffs to 10 feet 10 miles back from the edge of the escarpment. Beyond ten miles it rapidly drops to 2 to 3 feet thick and continues thus over a large part of the State. The till varies in thickness but has the general average of 20 feet. In some places the loess has been removed and the till occurs on top, *e. g.* at the shallow well of the Belleville Water Works in the valley of Richland creek.

SECTION ON RICHLAND CREEK.

	Feet.
Yellow till	25
Black muck, resembling soil	2
Yellow clay	6
Blue clay	9
Total drift	42

At this point the well entered rock. Other typical wells are as follows:

SECTION OF COAL SHAFT OF THE SOUTHERN COAL MINING COMPANY, SHAFT NO. 5, BELLEVILLE, ILL.

	Feet.
Soil, black	12
Clay, yellow	30
Clay, blue (had to use pick)	66
"Soapstone"	9
	117

SHAFT OF EDWARDSVILLE COAL COMPANY (MADISON MINE), EDWARDSVILLE, ILL.

	Feet.
Soil, black	3
Clay, (red brick color) till	26
Clay, blue, sandy	9
Hard pan and gravel	30
Soft clay	1
"Slate metal"	16
Sandstone	15
	100

In the last example water was found 25 feet below the surface. No other water was encountered in sinking the shaft down to 222 feet, which is the depth to coal bed No. 6. This depth to surface water is the general average throughout that part of the upland within the district. In this region fifteen coal shafts and a representative number of the shallow wells and all of the deep wells visited, and 25 feet was found to be the general average depth to water. More than that it is the only water-bearing horizon of importance above the 400 feet level. The latter level is considered under deeper horizons.

CITY AND VILLAGE WATER SUPPLIES AND SYSTEMS.

[BY CHESTER A. REEDS.]

The discussions of the preceding pages are based on facts, many of which pertain to the water conditions and resources of cities and villages. Not all the facts relating to the water systems of towns were relevant to the discussions, however, and such were therefore omitted. They are included here, for the convenience of well owners and communities who have an interest in these systems beyond that part included in the preceding discussion. Some of the systems are very simple indeed and require a short paragraph only, while others, especially those of the larger towns, Belleville, Alton, etc., require extended discussion. Occasional recommendations are made for the improvement of the water system.

Belleville.

The city of Belleville is a railroad center, and the county seat of St. Clair county, Illinois. It is located on high ground on the Louisville & Nashville, Southern Illinois Central and East St. Louis & Suburban electric railroads, 14 miles southeast of St. Louis, Missouri. It contains several breweries and distilleries and extensive manufacturers of stoves, nails, flour, steam engines, threshing machines, pumps, drills, glass, shoes, powder, vinegar, etc. The city is underlain by workable bituminous coal of a good quality. Along the railroads numerous shafts have been sunk which supply an immense amount of coal used in St. Louis and East St. Louis. These mines support the large mining population residing in Belleville, which in 1890 was 15,360; in 1900, 17,484; in 1906, 20,000 reported.

The city water is furnished in part from artesian wells drilled in the valley of Richland creek and in part by impounded water from Richland creek and its tributaries. The impounded water, used to sprinkle the streets and in some cases for the locomotives on the railroads, is brought into the city through an old system ten miles in length, and was the principal source of supply preceding the advent of the deep well system. The present system pumps water from 18 of the 30 wells which the Belleville Deep Well Company has sunk, and distributes it over the city through the ten miles of old and 30 miles of new mains. The water is raised from the wells to a nearby reservoir by means of electrical driven pumps. The stored water is then forced to all taps of the system by the pressure in the reservoir.

In addition to the 30 wells of the Belleville Deep Well Water Company, 16 other deep wells have been sunk in and near Belleville. These are operated by the manufacturing plants which consume an enormous amount of water in making their products. A list of the well owners with the number owned by each is given in the following table:

WELLS AT BELLEVILLE, ILL.

Belleville Deep Well Water Co	30
Belleville Distillery	2
Western Brewery	3
Star Brewery	3
Harrison-Switzer Mill	1
Gas and Electric Company	1
Citizens' Ice Company	1
St. Clair Vinegar Company	2
St. Clair County Farm and Hospital	1
American Bottle Company	1
Belleville Stove and Range Company	1
	46

Of the foregoing number 15 have been abandoned chiefly because they furnished an insufficient supply of water; 12 of these belong to the Belleville Deep Well Water Company and three to the Star Brewery.*

The depth of these deep wells varies from 400 to 700 feet, depending (1) upon the unevenness of the surface, (2) the dip of the water-bearing stratum to the east, and (3) the will of the owner and driller at the time the well was sunk.

Along Richland creek in the southwestern and southern parts of the city the mouth of the wells is approximately 480 feet above tide; while in the western part in the vicinity of the plants, the elevation is slightly above 540 feet; in the northeastern part in the neighborhood of the Star Brewery, the elevation above sea is a little more than 540 feet. It can be seen, then, that between the lowest and highest points there is a difference i nelevation of approximately 60 feet.

From the logs of wells secured at Belleville and adjoining towns, it is plain that the water-bearing stratum dips to the east; and comes near the surface some 12 miles west of Belleville just east of the Karsted district which extends from Falling Springs south past Waterloo to Thebes, Illinois. Where this outcrop of water-bearing sandstone appears the whole country is covered with porous glacial material, loess, add probably with brown loam or till, so that it is somewhat difficult to determine whether it discontinues. This geological fact is important, however, since it enters largely into the problem of locating the source and amount that can be furnished to Belleville through the water-bearing sand stratum. This water-bearing horizon dips to the east in conforming to the gentle slope of the western rim of the Eastern Interior Coal Field. From an incomplete section of the deep wells at Millstadt, Illinois, it was ascertained that the 70-80 feet of sandstone overlying the 300 feet of hard limestone was 230 feet below the surface of the ground and that the bed just above it was composed of shale. In the wells of the Belleville Deep Well Water Company in the valley of Richland creek in the southwest part of the city, a sandstone stratum occupying the same relative position with reference to the adjacent beds at Millstadt was struck 400 feet below the surface. In a deep well on the Muren farm, one and a half miles northeast of the wells, near the pumping station, 87 feet of sandstone was found at a depth

*For detailed information of each well, see well statistics, page 73 et seq.

of 514 feet, immediately overlying the 986 feet of solid limestone below. At Mascoutah, Illinois, ten and a quarter miles east of Belleville, 20 feet of sandstone was encountered at a depth of 730 feet in contact with the 500 feet of massive limestone below. In this well, however, salt water was present in a 45 foot stratum of sand, 545 feet below the surface of the ground. The 140 feet of intercalated material is composed of limestone and shale as in the other wells cited above. This evidence goes to show that there is a decided dip of the water-bearing stratum from the west toward the east. This is shown in Fig. 2.

In sinking wells to this stratum of sand the owners and drillers were oftentimes unmindful of the above mentioned geological features. Hence, when a reasonable supply of good water was found, they decided that a test was needless, for, by going deeper. an amount large enough to meet all demands could be obtained. As they went deeper, however, the good supply was cased off and salt water took its place. In some case, too, the driller was aware of an abundant supply of good water, but cased it off for the rig having once been set up, the deeper the well the greater the profit to the driller.

Water is found in some of the sandstone strata that occur higher up, but usually not in paying quantities. For this reason, most of the wells are sunk to the water bearing-stratum of sandstone which occurs immediately above the thick massive limestone previously mentioned. This heavy limestone is probably Mississippian, while the overlying sandstone is probably the "Millstone grit" found immediately below the coal measures. The water obtained from this sandstone in Belleville is of a fine quality. For the chemical analysis of representative samples, see table.

The amount of water in the Belleville wells is decreasing. Mr. Slocum, superintendent of the Belleville Deep Well Water Company, states that in 1898 there were but two deep wells drawing water from this horizon, and that the head was 300. In 1905 there were 31 wells in Belleville drawing water from this depth with a head of only 150 feet. This loss of head is probably due to two causes: (1) the increased number of wells, (2) the pulling of casings from abandoned wells. The fact that there is a head of water to consider is due to the existing artesian conditions. In its dip to the eastward, the porous water-bearing stratum, from which the water is pumped, is overlain throughout by an impervious layer of shale which keeps the water confined. Hence, when the deep wells at Belleville tap this stratum the water rises until the column of water in the wells balances the pressure of the water in the water-bearing stratum. In sinking many wells to such a stratum the tendency is to draw off great quantities of water in a short time; on the other hand, the water which feeds these wells travels very slowly through the porous sand, not less than 200 feet and not more than one mile during the year. Under such conditions it is not surprising that the head of water is decreasing, and after steady pumping the sand "feels dry."

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*For complete section of the wells see well statistics. page 73 et seq.

The pulling of casing from abandoned wells permits the water in an artesian district to rise in the holes to the next pervious stratum and escape. In the several logs of abandoned wells belonging to the Belleville Deep Well Water Company, furnished to this survey by Mr. Slocum, the height of the impervious stratum above the water-bearing ones varies. In well No. 21 there is 134 feet of shales between the water-bearing sandstone and the next overlying sandstone or pervious stratum in which the water might escape. In this case the water-bearing stratum is 34 feet thick and produced only 9,000 gallons per day, an amount insufficient for economical equipment and operation. In well No. 22, which has been abandoned, there is 195 feet of shale between the water-bearing sandstone and the one overlying. Here, too, the depth of the water-bearing stratum is thin (23 feet), affording only 9,000 gallons per day. This well was sunk near well No. 19 46 days after well No. 19 was completed. The logs of the two wells are almost identical, the thickness of the strata being the same. No. 19, however, afforded only 4 gallons per minute or 5,760 gallons per day, while No. 22 afforded 9,000 per day. Although the yield of each abandoned well is not great, the combined yield of 12 is sufficient to assist greatly in lowering the head of the water in the productive wells.

Edwardsville.

Edwardsville, Illinois, with its good water, excellent sewer, and transportation facilities should make a choice resident site for the busy merchant of St. Louis or East St. Louis. The water forced through the mains in the city is supplied by a private company, which obtained its franchise April 5, 1898. On January 26, 1899, the present system was in working order and ready for a trial test. That test consisted of throwing water from four lines of hose, simultaneously, to a height of 130 feet, or 40 feet more than required by ordinance.

Plant. The five wells and pumping station are located at Poag in the "American Bottoms," six miles west of Edwardsville. The water is drawn from five 8-inch casings, which reach through sand to a depth of 54 feet. The water runs into the wells through a 20-foot Cook strainer placed at the bottom of each well. Water is not pumped continuously from any one or two of the wells, as it has been found in various tests that the water flows into them very slowly. This may be due to the smallness of the screen openings, but more probably to the slow transmission of the water through the sand ridge constituting the water-bearing stratum. The first 18 feet of this ridge is composed of fine sand and silt. That below 18 feet is gritty and would make a good plastering sand. It is this gritty sand which is the water-bearing medium, for the water table is about 18 feet below the surface at this place. The wells, pumping, station, and reservoir are arranged with reference to one another as shown in the accompanying diagram, Fig. 10.

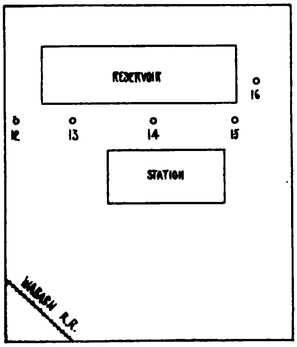

FIG 10. Edwardsville pumping station at Poag.

In constructing the pumping station the engineers endeavored to make it as nearly as it is possible like a model station. The building is of pressed brick with facings of cut stone. It is 30 feet wide, 56 long, and 25 feet high. In the center of the pump room, which is 30 feet square, is the pump pit, a concrete well 21 feet in diamater. Here are two duplex Gardner pumps, each with a capacity of 1,000,00 gallons a day. The boiler house adjoining is supplied with a double bank of powerful boilers, which supply the force for carrying an immense amount of water to Edwardsville. A telephone line from the station to the local exchange furnishes a complete fire alarm and enables the engineer to know when to pump water out of the reservoir used only in the case of fire.

Mains. The pumping station at Poag is distant nearly six miles from the water tower in Edwardsville. A 12-inch main connects the principal points of the system. For the greater part of this distance the main follows the right-of-way of the Wabash railroad, as it could not be laid in the embankment used by the road. The pipe went through hills, along the bottom of swamps and sloughs, and up the heavy grades, which constituted lesser obstacles, to the water tower. From thepumping station to the base of the water tower there is a rise of 182 feet. From the water tower smaller pipes lead out over the city to supply the fountains, fire plugs, and taps. When the plant was installed the following amounts and sizes of pipes were used:

PIPE USED AT EDWARDSVILLE.

Length.	Size.
21,997 feet	12-inch
8,000 feet	10-inch
400 feet	8-inch
24,000 feet	6 inch
12,000 feet	4-inch

Water tower. The water tower that occupies the lots immediately adjoining the city building on Main and High streets is neatly fashioned. The foundation walls are 8 feet 6 inches across at the base; 3 feet 4 inches at the top, and are of hard brick laid in concrete. The tower itself is octagonal in form and an even hundred feet in height. It is built of pressed brick with bands of ornamental brick one-third and two-thirds the height, with a cap of the same. The walls at the bottom are 36 inches thick, tapering to 25 inches at the base of the cap. The tank which has a capacity of over 1,000,000 gallons is 36 feet high, by 22 in diameter, and is formed of plates varying from 7-16 to 5-16 of an inch in thickness. The over all dimensions of the tower are: Brick work, 100 feet; tank, 36 feet; roof, 12 feet, final, 4 feet; total, 162 feet. Small windows in each section afford light to the

stairway, which ascends on each side of the 10-inch feed pipe up the center of the tower. Around the outside of the tower at the base of the tank runs a balcony from which an iron ladder leads to the top of the tank.

Cost. One year after the company had obtained its franchise, "it had expended, April 14, 1899, $65,000. This amount does not include any expenditure for right-of-way or a single item for salary or work of any officer or stockholder. The plant was built at a time when material of all kinds was at the lowest point it had been for years. Iron pipe was worth only $14.50 a ton."

As the city grows larger the plant is increased to meet its needs. During the last few years one additional well has been put down at the pumping station and some of the city mains extended. There are, however, many people in the city still using cisterns and shallow wells. In a town as old and as large as Edwardsville there is much danger in using shallow water, since it is subject to contamination by surface drainage and percolating waters.

Water. The water supplied by the Edwardsville water works is a good potable water at the present time. When the wells were first sunk the water was found to have the right proportions of salts for good drinking water, except that it had too large an amount of nitrites. This amount has since decreased and the chemists now consider it a good drinking water. For analysis see p. 78-80.

At this writing there are only a few buildings on the long sand ridge at Poag from which Edwardsville draws her water supply. This is favorable for if the number of houses is allowed to increase the water is liable to be contaminated by surface infiltration.

Source of supply. The source of the water that flows into the wells at Poag has puzzled many investigators. In the light of present knowledge of undeground water this point has been somewhat cleared up. For detailed discussion as to its source see Water Resources of the Mississippi Flood-plain in this report.

In this connection the question arises—why can not Edwardsville secure as good a water supply from deep wells as Belleville? Wells have been sunk in Edwardsville as deep as 1,500 feet, but the water in every case is reported saline.

From the topography, it is evident that the district about Edwardsville is not suitable for artesian wells as at Belleville. In the case of Belleville the western edge of the water-bearing stratum is from 10 to 12 miles distant and at least 300 feet higher than where the water enters the wells. At Edwardsville wells of the same depth have water under less pressure since the massive limestone escarpment (200 feet high at Falling Springs and Alton) and a large part of the coal measures have been cut away from in front of Edwardsville by the action of the Mississippi river. Although this same sandstone member does appear under Edwardsville, its water is under less pressure and is somewhat saline.

Collinsville.

Collinsville, like Edwardsville, is situated on high ground overlooking theu "American Bottoms." It is a town of 5,000 inhabitants and has zinc works, coal mines, and manufacturers of brick, etc. It is located near the southern line of Madison county, Illinois, on the Vandalia railroad, and East St. Louis & Suburban electric line, 12 miles E. N. E. of St. Louis, Missouri. Throughout this district the city is noted for its saloons, 49 in number. Although there are said to be more than 5,000 people living there, it is stated that not a single foot of sewer exists within the town. With reference to the water supply, however, more heed has been paid.

In 1889, a well 602 feet deep was sunk. Water was obtained from a 64-foot stratum of sandstone, the top of which was 509 feet below the surface. The water was not of the best quality for it was slightly saline. The supply being small and the quality poor, a second well, 571 feet in depth, was put down in 1895, to the east of the former well. The water obtained was similar to that found in the first well. The combined capacity of the two being not more than 20,000 gallons a day, they were abandoned. The pumping apparatus is still kept in act, however, and the water used in case of fire.

Another deep well has been sunk northeast of the town at the St. Louis Smelting Company's plant. This reaches a depth of 716 feet and affords a poor quality as well as a scant supply of water. The fact that the three wells yield an insufficient quantity and are saline tends to prove the assertion that there can be no successful artesian wells here at this depth.

Following the lead of Edwardsville, the Water Company of Collinsville sunk wells in 1901, in the "American Bottoms," near the Madison-St. Clair county line, about one-fourth of a mile from the bluffs. Four 10-inch wells were sunk to a depth of 90 feet by the same method used at Poag, and are arranged with reference to one another as shown on the map, Plate 4. The first 15 feet of earth taken out of the casing represents a soil white in color. It appears to be reworked material deposited by the small streams coming out of the bluffs. The remaining 75 feet showed a reddish sand, without doubt part of the alluvial deposits of the Mississippi. A number of tests as to the capacity of these wells has been made and it has been found that any one of the four wells will yield 1,000,000 gallons in 24 hours. The water leaves a red deposit on the porcelain bath tubs and wash bowls and a soft red scale in the boilers. This scale seems to be due to an overabundance of iron in the water. For analysis of the water see p. 97.

The cost of the old plant was approximately $20,000 This included two deep wells, pumping station, mains and water tower. The new plant with the four wells, pumping station, mains to city, and additional mains in the city, cost $33,000. The water tower and mains of the old plant are being used as a part of the new system.

Collinsville has made its chief growth during the last 20 years. Taking into account the age of the town, 100 years, and the fact that it has never had a sewer system, and it is surprinsing that approximately one-half of the population still use water from shallow wells.

Caseyville.

Caseyville has 500 inhabitants and is located at the foot of the bluff, nine miles east of St. Louis, on the Baltimore & Ohio and Vandalia railroads, and the East St. Louis & Suburban electric railroad. It supports largely a coal mining population. There is no water or sewer system. Shallow wells from 25 to 40 feet deep afford an abundance of water.

Alton.

Alton, with approximately 20,000 people, lies in the northern part of the district, on the Mississippi river, three miles above the mouth of the Missouri and 25 miles above St. Louis. It is on the Chicago & Alton, Chicago, Burlington & Quincy and the Cleveland, Cincinnati, Chicago & St Louis, the Alton-East St. Louis electric and other railroads. It is situated on a high limestone bluff which rises about 200 feet above the river and is built on hilly uneven ground It has a public library, parks and a collegiate institution. It has flouring mills, glass factories, packing houses, and manufactures of machinery, carriages, farming implements, lead, lime, cement, tobacco, paving brick, etc. A number of valuable quarries of limestone are located along the river above Alton. It is the market and shipping point of several counties from which lime, coal, building stone, and fruits are exported.

The city gets its water supply from the Mississippi river through a system similar to the ones in use at East St. Louis and Granite City. The pumping station and filtering basins are located on the north bank of the river a mile above the city. From here the water is forced through a 16-inch pipe for one-half a mile over the high bluffs to two large galvanized iron tanks where it is stored. These in turn give out the water to the various mains leading over the city. At the present time there is not a sufficient number of filtering basins to filter all of the water needed. To supply this deficiency, unfiltered water is pumped directly into the mains, tending to make the water muddy and necessitating frequent flushing. At the time the plant was installed it was sufficiently large to supply the city's wants, but the filtering capacity has not been increased with the growth of the city. In the near future, however, four additional filters are to be added, thus insuring Alton good, wholesome water.

The position of the pumping station with reference to the river, and the relation of its various parts, are shown in the diagram, Fig. 11. The intake pipe rests on a rock foundation 3½ feet below low water mark. By a nice arrangement of dikes in the Mississippi river, above the plant, a strong current is thrown past the station which keeps the intake pipe free from sediment. The water is pumped from the Mississippi river into a well 20 feet in diameter through a 24-inch pipe 100 feet long. From the well the river water is raised into the settling basin where it is treated with solutions of lime and sulphate of iron, which reacting with each other and with substances in solution form a precipitate which carries down the matter held in suspension. The amount used varies with the condition of the water. On May 31, 1906, 1,102 pounds of lime and 334 pounds of sulphate of iron were used to precipitate the suspended matter carried in 2,500,000 gallons of river water. The lime and sulphate of iron run constantly into the settling basin through iron pipes leading off from separate dissolving vats located above, and at the east end of the basin.

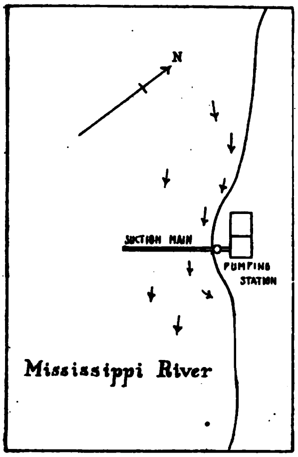

FIG. 11. Pumping station at Alton.

From the settling basin the water runs over into the filtering room, where six of the New York gravity type of filters are. These filters are each 15 feet in diameter, 8 feet deep, and are filled with sand to a depth of 5 feet. The sand is taken from the river, but is cleaned before being put to use in the filter. When the water has percolated through the filters, it is raised 240 feet into the reservoir situated on the hill northwest of the city.

The plant was completed nine years ago at a cost of $220,000.

East Alton.

East Alton is a village of approximately 550 people in the northern part of the district, four and one-half miles east of Alton. It is a railroad junction and manufacturing town. The Union Cap and Chemical Company, The Equitable Powder Manufacturing Company and Beal Brothers' Tool Shops located along Wood river in the northern part of the town give employment to a large portion of the population.

The water supply is obtained from private wells scattered over the village. In most cases these are driven to a depth from 18 to 25 feet through the sandy loam and quicksand which have been deposited near the junction of the east and west forks of Wood river. The manufacturing plants obtain their water supply from wells, although some is taken from Wood river.

In 1894 the Big Four railroad sank a well at its station in East Alton to a depth of 54 feet. In drilling this well the following strata were encountered.

Sand	30-35 feet
Quicksand	12-18 feet
Sand	12-18 feet
Clay (blue fire clay)	4 inches

The drill hole was 8 inches in diameter and afforded plenty of water for the use of the road at that time. In 1906, however, another 8-inch well was sunk to the same depth, 100 feet north of the former one.

In 1906 the Equitable Powder Manufacturing Company put down a well to 900 feet on their property just across Wood river north of town. After the first 80 feet drift rock or varying texture was encountered to 900 feet. Some of the rock was soft, but the greater part of it was a hard limestone. A salty water was obtained somewhere below 625 feet which ruined the supply for boiler and condensing purposes.

In sinking the well an 18-inch crevice was encountered at the 625-foot level. In endeavoring to sink the well deeper, the drill hole was deflected, necessitating a "shot" to straighten out the diffiucutly. As a result of this shot a large quantity of good water was obained. The company did not put in a test pump at this time but continued drilling until the 900-foot level was reached. Then in a trial test 27½ gallons were pumped every minute for 24 successive hours. During this time the water was not lowered. On account of its salinity, however, it is of little use.

Glen Carbon.

The water supply of the village is dependent upon shallow wells located on the hills as well as in the valley of Judy's branch. Water for the boilers at the coal mines and for the washer is obtained from the branch and from ponds which have retained flood waters. The wells on the hills are the deeper while those in the valley, although not so deep, have more water in them. The wells on the hills average 56 feet in depth, with four feet of water, while those in the valley are 30 feet deep with 25 feet of water. Most of the wells are owned by the Madison Coal Company and are one of two sizes, either walled with 18-inch tile or with brick. With the brick walled ones, the diameter is usually 3½ feet.

Water has not always been plentiful in Glen Carbon and on various occasions the coal company has been compelled to haul water from East St. Louis. To insure a constant supply for the coal washer, dams are being built across Judy's branch. After a few years, however, it is probable that the lake thus formed above the dam will be filled with sediment and no flood water can be caught. The coal company will then be forced either to build additional dams or put in a system similar to that furnishing water to Edwardsville and Collinsville.

East Carondelet.

East Carondelet is a small village in the "American Bottoms" in the southern part of the district, on the Mobile & Ohio and Illinois Central railroads. Its water supply is obtained from shallow wells driven into the alluvial deposits to a depth of from 25 to 30 feet.

O'Fallon.

O'Fallon has approximately 2,000 people, in the southern part of the district on the Baltimore & Ohio Southwestern, Louisville & Nashville and East St. Louis & Suburban electric railroads. It is on level ground with an elevation of approximately 570 feet above tide. It has manufactures of stoves, ranges, flour, etc. The coal mines in the immediate vicinity support a large part of the population.

The water supply of the town is obtained from shallow wells in the glacial drift. The O'Fallon Electric Light and Water Company have put in a small plant which supplies the business and part of the residence portion of the town with water. The pumping station and wells are located in the extreme western part of the town near the crossing of the Baltimore & Ohio Southwestern and Louisville & Nashville railroads. In 1894 the company put down three 8-inch wells to a depth of 40 feet. At the bottom of each there is an 8-inch strainer of the Cook type. This was a necessity as quicksand was found at this depth. See section of well given below:

	Thickness.	Depth.
Brown loam	35	35
Black clay, hard, tough	1	36
Quicksand	3	39

The capacity of each of the wells is approximately 22,000 gallons per day.*

Not far distant from the wells of the Water Company is a single well belonging to the Charles Tiedman Milling Company which supplies water to the flour mill. This is a dug well 40 feet deep, 4 feet in diameter, and has an approximate capacity of 2,500 gallons per day. The chemical analysis of the water of the wells at the pumping station and of the mill are given on a later page.

Mitchell.

Mitchell is a small village on the "American Bottoms," seven miles north of East St. Louis. The Wabash, Chicago & Alton, Cleveland, Cincinnati, Chicago &St. Louis, and East St. Louis & Suburban railroads pass through it. The few inhabitants obtain their water supply from wells driven into the alluvial deposits to a depth of from 25 to 40 feet. One mile north of Mitchell on the Big Four railroad a 3-inch well sunk to a depth of 56 feet supplies water for the engines on that railroad. These wells are on a sand ridge which runs south from Wood river to Mitchell and then east along the north side of Long lake.

*For further data see table of well statistics, p. ——.

Nameoki.

Nameoki is a small village half way between Granite City and Mitchell on the flood-plain of the Mississippi river. Its water supply is derived from wells driven into the flood-plain deposits to a depth of from 25 to 60 feet. The water is not of the best quality.

East St. Louis.

In the section on surface sources of water supply will be found a discussion of the principal features of the East St. Louis, Granite City and Madison water supply. The following data were not pertinent to the discussion in that chapter and are therefore included here.

The present system was established in 1885 by a private company which has ever since retained control. L. S. vertical direct-acting pumps are used with a combined capacity of 22,000,000 gallons in 24 hours; 8,000,000 gallons of water are consumed daily. Weekly analyses are made by the chemist steadily employed by the company. There are 7,600 consumers of the water thus supplied.*

Granite City.

The system supplying water to Granite City has already been referred to in the description of the water supply of East St. Louis. The City Water Company of East St. Louis and Granite City maintains two pumping stations, one at East St. Louis and one at Granite City. The former supplies water to East St. Louis alone, the latter to Granite City, Madison and Venice. The pumping systems and filtration methods are so nearly alike as not to warrant repeated description here.

Oher Towns and Villages.

The water resources of the other smaller towns in the area, Peters, Stallings, Dupo, and the like, are so exceedingly simple as not to require separate discussion. In all cases the supply is from relatively shallow wells owned by individuals. There is no approach to a public system. The sanitary arrangements, while in most cases primitive, do not demand special condemnation, because of the relatively scattered population. Any further growth of population in the small towns, however, will call for a public system of water supply, adequately protected and complemented by a suitable drainage system.

ANALYSES AND WELL SECTIONS.

ANALYSES.

In the pages and tables following are given such sanitary and mineral analyses of the waters of the district as are available. The larger portion were made in the laboratory of the State Water Survey, the samples being in part collected by officers of the Geological Survey and in part sent in by private citizens. The first thirteen analyses given

*From data supplied by Dr. E. Bartow, the director of the State Water Survey, Urbana, Ill.

were furnished by the well owners, and are given here as supplied to the survey. For purposes of comparison they have been recalculated in the ionic form, and in this form appear in the table of mineral analyses. Following them are analyses made in the laboratory of the State Water Survey.

MISCELLANEOUS MINERAL ANALYSES.

WELL NO. 41.

Corn Products Company, Granite City.

	Grains per Gal.
Silica	6.76
Oxides of iron and aluminum	1.80
Lime (calcium oxide)	8.75
Sodium oxide	3.148

Analysis by St. Louis Testing and Sampling Co.

	Parts per 1,000,000.
Total solids	532.8
Volatile solids	52.2
Fixed solids	480.6
Silica	26.4
Oxides of iron and aluminum	11.6
Lime	157.5
Magnesia	48.3
Alkalies	15.8
Sulphuric anyhdride	84.6
Chlorine	18.0
Carbonic acid	139.3
	501.5

WELL NO. 42.

American Steel Foundry Company's Well Water. From Dearborn Laboratories, Dec. 19, 1904.

	Grains per Gal.
Silica	1.495
Oxides of iron and aluminum	.543
Carbonates of lime	6.155
Sulphate of lime	17 680
Carbonate of magnesia	6.423
Sodium and potassium suplhate	.788
Sodium and potassium chlorides	2.970
Loss on ignition probably	.514
	36.558

WELL NO. 45.

Rolling Mills, Granite City.

	Grains per Gal.
Sodium chloride	.96
Calcium sulphate	6.85
Sodium carbonate	4.63
Calcium carbonate	9.14
Magnesia (carbonate?)	4.60
Silica	1.72
Oxides or iron and aluminum	1.72
	29.62

WELL No. 46.

American Car & Foundry Company, Madison.

	Grains per Gal.
Sodium chloride	1.69
Calcium sulphate	4.50
Calcium carbonate	10.49
Magnesia (carbonate?)	6.81
Silica	2.33
Oxides of iron and aluminum	1.57
	27.39

American Car and Foundry Co.

Cold Water, Deep Well.

	Grains per Gal.
Sodium chloride	1.92
Calcium sulphate	5.48
Calcium carbonate	10.90
Magnesia carbonate	5.59
Silica	1.86
Oxides of iron and aluminum	.87

Pond Water, Madison.

American Car and Foundry Company.

Sodium chloride	1.34
Calcium sulphate	10.25
Sodium carbonate	1.75
Calcium carbonate	1.86
Magnesia (carbonate?)	6.00
Silica	1.46
Iron oxides and aluminum	.76
	23.42

WELL No. 44.

Analysis of water from 250 foot well by the chemist of the Commonwealth Steel Company of Madison. Well, the property of the Hoyt Metal Company of that city. Below limestone. Taken in platinum dish so that there would be dissolving of glassware.

500 g. gave .0109 grams per litre. SO_3 = .6358 gr. per gal.

1,000 grams + evap. to dryness = .3086 gr.

Total solids, 18.0022.

1,000 grams organic matter + water = .0423 gr., dried, 102° = 2,4676.

	g. per litre.		g. per gallon.
1,000 grams solids, etc	0.3080		
1,000 grams insol. residue	.0237		
1,000 grams silica	.0235	=	1.3709
Iron oxide and aluminum	.0002	=	0.0116
1,000 grams lime	.1028	=	5.9968
1,000 grams magnesia	.0274	=	1.5983
500 grams of water clorine	.0059	=	.3381
1,000 grams calcium sulphate	.0182	=	1.0616
1,000 grams calcium carbonate	.1700	=	9.9169
1,000 magnesium (carbonate)	.0503	=	2.9342
1,000 grams magnesium cloride	.0078	=	.4549

WELL No. 28.

Sample of water from 380 feet analyzed by R. W. Starke, as follows: Urbana, September 25, 1902. Sanitary chemical analysis.

(Amounts stated in parts per million.)

Total residue by evap	18,592.4
Fixed residue (mineral water)	17,820.8
Volatile matter (loss on ignition)	1,131.6
Chlorine in chlorides	8,400.0
Oxygen consumed	48.1
Nitrogen as free ammonia	5.8
Nitrogen as albuminoid	.08
Nitrogen as nitrites	.001
Nitrogen as nitrates	.079

Much sulphate. Excessive amount of mineral water makes it unfit for boiler or for ordinary drinking purposes. Upon surface of water was noticeable a film of what appeared to be oil.

WELLS No. 102, 103.

Belleville, June 10, 1901. St. Clair Vinegar Co.

	Parts per million.
Carbonate of sodium	811.5
Carbonate of lime	22.7
Carbonate of magnesia	Traces
Chloride of sodium	42.6
Sulphate of sodium	14.3
Silica	21.4
Volatile matter	53.2
Ammonia	None
Nitrites	None
	965.7

Analyzed by Zymotechnic Institute, Chicago.

Some difficulty with water for vinegar purposes. Carbonate of soda must be neutralized by acid. To neutralize carbonate of soda it requires 1.36 pounds of muriatic acid, (*i. e.* H Cl. of 33% strength) for every 100 gallons of H_2O.

WELL No. 193.

Ph. H. Postel Milling Co.:

GENTLEMEN—We have made a complete analysis of the sample of water sent us, including a quantitative determination of the amount of solid residue per gallon, and beg leave to report as follows:

Total mineral matter, 1,706.5 grains per gallon.

This residue is composed chiefly of chloride of sodium or common salt, which would probably amount to 1,500 grains per gallon. The residue also contains:

Sulphate of lime, sulphate of magnesia, oxides of iron, slight.

This is a brine carrying all of its salt in solution. On long standing a portion of the iron is deposited as oxide. The water is unfit for drinking purposes, wholly useless as a water for steam purposes and therefore valueless as a source of water supply.

Respectfully,

REGIS CHAUVENET AND BROS.

Analysis by C. Leudeking.

The following are the results of my examination of the sample of artesian water you forwarded me.

	Grains per U. S. gallon.
Chloride of sodium	1,041.21
Chloride of potassium	15.33
Bromide of sodium	2.74
Iodide of sodium	.46
Bicarbonate of lithium	Trace
Bicarbonate of iron	.29
Bicarbonate of sodium	3.55
Bicarbonate of magnesium	96.97
Bicarbonate of calcium	184.28
Sulphate of sodium	71.09
	1,415.92
Total solids, direct determination	1,409.06
Sulphuretted hydrogen gas, per gal	3.1 cu. in.
Free carbonic acid gas, per gal	14.9 cu. in. (?)
Density of water	1.017

Reaction slightly alkaline.

Respectfully,

C. LUEDEKING.

Stanford, Conn., Aug. 12, 1895.

SECOND ANALYSIS OF WATER FROM DEPTH OF 3,000 FEET.

By Regis Chauvenet and Bros.

April 27, 1895, 709 Pine St., St. Louis.

	Grains of solid residue per gal.
Sodium chloride	694.49
Calcium chloride	391.80
Magnesium sulphate	130.50
Calcium sulphate	76.05
Oxide of iron	0.76
	1,293.60

Hydrogen sulphide gas strong on first drawing from well. Organic matter of either vegetable or animal origin wholly absent. This is a strongly saturated magnesium water. It is chiefly characterized by the common salt in solution which makes it a brine to the taste, wholly unpalatable and likely to prove purgative in its action. It is perfectly wholesome water as far as its constitutents are concerned and free from organic contamination of any kind. It may be compared with the famous Saratoga wells, being not unlike the Congress or Empire spring. It must remain for the medical profession to indicate how freely such extremely salt water may be safely used. As a water for boiler use it is wholly unfit, but as a source of common salt it may find a use, though the per cent of lime and magnesia interfere with the purity of the product first obtained.

The sulphuretted hydrogen gives to the water a characteristic smell and color, and to such a strongly impregnated sulphur water the name "Blue Lick" water is commonly given. We suggest that you call it "Magnesium Sulphur Water" as the best name to indicate its nature.

Respectfully,

REGIS CHAUVENET AND BROS...

SANITARY ANALYSES FROM STATE WATER SURVEY.

The following analysis from the Department of Chemistry, University of Illinois, and the discussions accompanying them are included here because the samples are from various places in the district, and are, therefore, fairly representative of water qualities for the shallow depth from which most of the samples were taken.

CHEMICAL ANALYSIS.

UNIVERSITY OF ILLINOIS, URBANA, ILL., Feb. 16, 1898.

Laboratory No. 3261.

Report of the sanitary chemical analysis of water sent by Chas. Boeschenstein, Edwardsville, Illinois. Sourse of water 55-foot driven wells at Poag, Illinois. Samples No. 3261 taken Feb. 14, 8:00 a. m., after 213 hours continuous pumping. Amounts stated in parts per million:

	No. 2973	No. 3045	No. 3044	No. 3064	No. 3261
Total residue by evaporation	160.	157.6	154.	152.	154.
Fixed residue (mineral matter)	136.8	141.2	138.	134.	136.
Volatile matter (loss on ignition)	23.2	16.4	16.	18.	18.
Chlorine in chlorides	3.2	2.9	2.9	2.9	2.7
Oxygen consumed	1.0	1.2	1.1	.9	1.1
Nitrogen as free ammonia	.001	.002	.002	.001	....
Nitrogen as albumenoid ammonia	.014	.024	.024	.014	.003
Nitrogen as nitrates	.033	.014	.023	.014	.003
Nitrogen as nitrates	3.0	3.6	3.6	3.6	3.4
Date of collection	Nov. 21	Dec. 6	Dec. 10	Dec. 11	Feb. 14

The last sample, No. 3261, shows great improvement over the earlier samples with respect to nitrites, and from consideration of all the circumstances, it is my opinion that the nitrites have been in the main developed in the water after drawing from the well and while in transit to the laboratory here. Sample No. 3261 arrived and the test for nitrites was made here within nine hours of the time of collection, while in the other cases the time between collection and arrival here was from 24 to 96 hours.

ARTHUR W. PALMER, Sc. D.
Professor Chemistry.

SANITARY CHEMICAL ANALYSIS.

Water sent by Charles Boeschenstein, Edwardsville, Illinois.

UNIVERSITY OF ILLINOIS, URBANA, ILL., Feb. 5, 1898.

Laboratory No. 3224.

Source of water 35-foot, open well, on north side of court house square, Edwardsville, Illinois. Amounts are stated in parts per million:

Total residue by evaporation	593.2
Fixed residue (mineral matter)	477.2
Volatile matter (loss or ignition)	116.0
Chlorine in chlorides	99.0
Oxygen consumed	1.5
Nitrogen as free ammonia	.002
Nitrogen as albumenoid ammonia	.024
Nitrogen as nitrites	.008
Nitrogen as nitrates	22.0

Considerable sulphate.

The very high chlorine and the excessive nitrates in this water show that the supply comes originally from a surface area which is near by, and which is contaminated by animal refuse matters. Inasmuch as the albumenoid is low, however, it appears that the organic matters are quite fully oxidized before they reach the well. The water may be regarded as usable condition, at the present moment, but such waters as this are a source of danger inasmuch as at any time organic matters are likely to reach the well before becoming completely oxidized and consequently causing pollution and conveying disease.

A. W. PALMER,
Professor of Chemistry.

SANITARY CHEMICAL ANALYSIS.

Water sent by Chas. Boeschenstein, Edwardsville, Illinois.

November 6, 1897.

Source of water 55-foot driven well near Edwrdsville, Illinois. Amounts are stated in parts per million. Laboratory No. 2891.

	Filtered.
Total residue by evaporation	138.
Fixed residue (mineral matter)	120.4
Volatile matter (loss or ignition)	17.6
Chlorine in chlorides	2.1
Oxygen consumed	4.6
Nitrogen as free ammonia	.004
Nitrogen as albumenoid ammonia	.056
Nitrogen as nitrites	2.200
Nitrogen as nitrates	1.600

Little sulphates.

The high "oxygen consumed" and "albumenoid ammonia" show that much organic matter is present while the excessive nitrites show that putrefactive changes are going on actively. In its present condition this water could not be considered suitable for domestic use, but undoubtedly the present condition is not at all normal. You must not expect to gain knowledge of the true condition of the water from wells of this class until the wells have been thoroughly pumped for a day or two.

A. W. PALMER.

SANITARY CHEMICAL ANALYSIS.

Water sent by C. Boeschenstein, Edwardsville, Illinois.

No. 2973. Nov. 30, 1897.

Source of water, 50-foot driven well at Poag, Illinois. Amounts are stated in parts of millions.

Total residue by evaporation	160.
Fixed residue (mineral matter)	136.8
Volatile matter (loss or ignition)	23.2
Chlorine in chlorides	3.2
Oxygen consumed	1.0
Nitrogen as free ammonia	.001
Nitrogen as albumenoid	.004
Nitrogen as nitrites	.038
Nitrogen as nitrates	3.0

This water contains a very small quantity of mineral matter and consequently would probably be well suited for use for mechanical purposes. The low proportion of free and albumenoid ammonia, also of chlorine, indicates that the water is comparatively free from organic impurities, but the presence

of so much nitrites is unfavorable, as it indicates that the organic matters present are undergoing oxidation. It is quite likely that this condition of affairs may be improved after long continued pumping. The water appears to be derived from a shallow source and doubtless is collected from a surface area which is not very far distant from the well itself. It is, I should say, essentially a land water, that is, it is unlikely that the water manifesting these characteristics comes from the river underground, but rather is derived from a land stream flowing toward the river.

A. W. PALMER.

SANITARY CHEMICAL ANALYSIS.

Water sent by Chas. Boeschenstein.

No. 2974. **Nov. 30, 1897.**

Source of water, 90-foot shaft, abandoned coal mine, Wanda, Illinois, after continuous pumping for three weeks. Amounts are stated in parts of millions:

	No. 2974	No. 2731
Total residue by evaporation	979.2	1264.8
Fixed residue (mineral matter)	928.4	1182.0
Volatile matter (loss or ignition)	50.8	82.8
Chlorine in chlorides	19.0	18.0
Oxygen consumed	2.1	8.0
Nitrogen as free ammonia	.56	.094
Nitrogen as albumennoid	.034	.454
Nitrogen as nitrites	None	None
Nitrogen as nitrates	.35	.4

Considerable iron and sulphates.

The water drawn from the shaft on the date of November 22 shows considerable improvement over the sample drawn from the same source about two months previously. The analysis of the number 2731 (which I have placed on this same sheet for purposes of comparison and which was the sample drawn from the same coal shaft September 30, and sent to us by Tuxhorn Brothers of Edwardsville) shows by inspection of the figures that there is a marked improvement in the character of the water at present, and it is quite likely that this improvement may continue. However, the large quantity of iron and sulphate in the water at present would be objectionable in a water that is intended for domestic use, and would also probably cause considerable difficulty if the water is used in boilers, because of formation of scale.

ARTHUR W. PALMER,

Professor of Chemistry, University of Illinois.

SANITARY CHEMICAL ANALYSIS.

Water sent by C. Boeschenstein, Edwardsville, Illinois.

Laboratory No. 3236. Feb. 10, 1898.

Source of water, 70-foot driven well on farm of Fred Whittig, near Edwardsville, Illinois.

Total residue by evaporation	194.0
Fixed residue (mineral matter)	184.0
Volatile matter (loss or ignition)	10.0
Chlorine in chlorides	3.0
Oxygen consumed	1.1
Nitrogen as free ammonia	**.002**
Nitrogen as albumenoid	.026
Nitrogen as nitrites	.105
Nitrogen as nitrates	.110

This water is very similar in character to the water drawn from the well at Poag. The excessive quantity of nitrites contained is a very objectionable feature of this water, inasmuch as the water was three days on the way, that is, collected February 4 at 10:00 a. m., and arrived at our laboratory February 7 at 8:30 a. m., it is likely that these nitrites either developed or at least were considerably increased in amount during transit. Consequently the significance of this datum can not be regarded as altogether satisfactory.

ARTHUR PALMER.

SANITARY CHEMICAL ANALYSIS.

Water sent by C. Boeschenstein, Edwardsville.

Laboratory No. 1454 and 1455. October 10, 1896.

Source of water, 35-foot test well, driven in sand and gravel at foot of bluffs (Gouthards). Amounts in parts per million:

	Oct. 5.	Oct. 6.
Total residue by evaporation	139.2	140.8
Fixed residue (mineral matter)	133.6	132.8
Volatile matter (loss on ignition)	5 6	8.5
Chlorine in chlorides	1.6	1.7
Oxygen consumed	.8	.6
Nitrogen as free ammonia	None	None
Nitrogen as albuminoid ammonia	.004	.006
Nitrogen as nitrites	.009	.008
Nitrogen as nitrates	4.00	4.00

This is comparatively soft water and is remarkably free from organic matters. If the water drawn from the well continues to exhibit such characteristics as it does at present it will make an admirable supply for your city. It seems to me that it will be well, however, in order to make sure that the supply continues of good quality, to send some more samples of the water collected at a later period.

Yours very truly,

ARTHUR W. PALMER,
Professor of Chemistry.

WELL No. 55.

Analysis of Well Water, Armour & Company, East St. Louis, Ill., July 7, 1906.

	Grains per U. S. gallon.
Sodium nitrate	.11
Sodium chloride	2.89
Sodium sulphate	2.02
Ammonium sulphate	.17
Magnesium sulphate	2.82
Magnesium carbonate	4.1
Calcium carbonate	25.72
Iron and aluminum oxides	1.35
Silica ($Si O_2$)	1.42

C. F. HAGEDORN,

Well No. 63.

Missouri Malleable Iron Co., Shallow Well, 72 Feet.

	City water, ½ Well Water, ½.	
	Parts per 1,000,000.	Grains per gallon.
Total residue	610.0	35.584
Ignition residue	350.0	20.147
Loss on ignition	260.0	15.168
Total hardness	266.667	15.556
Permanent hardness	82.325	4.804
Temperature	184.32	10.752
Chlorine	10.0	.583
SO_3 anhydride	75.92	4.428
Residue	33.50	....
Silica	33.50	1.954
Iron, Al	.11	.642
Lime	150.50	8.779
MgO	40.75	2.377

Well No. 39.

Otto Burget, 602 N. 10th St., East St. Louis.

Altoona, Pa., Feb. 25, 1905.

Water sample from Rose Lake, Illinois.

We have examined the sample of water taken from a 95-foot well at Rose Lake, Illinois. Find as follows as a boiler water:

	Grains per gallon.
Total solid residue	23.35
Probable scale making material in the above	21.14
Chlorine	0.11
Soda ash required per 1,000 gallons	None
Lime required per 1,000 gallons	1.95 lbs.

The residue consists principally of carbonates and sulphates of lime and magnesia, with a little free soda ash in the water, and a little bit of chlorides. We would not regard this as a very bad water for boiler use. Indeed, the small amount of free soda ash in it would assist in keeping the boilers clean, and in removing scale from other boilers. There is nothing corrosive to boilers in this water in its present condition.

As a drinking water this water contains as follows:

Nitrogen as nitrates (parts per million)	0.15
Nitrogen as nitrites (parts per million)	Trace
Free ammonia	0.36
Albumenoid ammonia	0.07
Chlorine (grains per gallon)	0.11
Bacteria (per cu. cm.)	3940.

Bacteria characteristic of bowel discharge not present.

There is nothing in these figures to cause any special uneasiness in regard to this water. It is noticeable that the free ammonia is high which is not at all rare in well waters in the coal region.

Chas. B. Dudley,
Chemist.

TABLE OF MINERAL ANALYSES.

The following table shows the results of analyses of the mineral content of waters from the East St. Louis district. These include 23 waters that were collected and sent to the State Water Survey by Messrs. Reeds and Bowman; 11 analyses made by other parties and recalculated according to the method used by the State Water Survey; and 17 analyses of waters that have been sent to the Water Survey by citizens of the district.

An inspection of these results show that wells over 500 feet deep contain an amount of mineral matter that would prohibit their use for boiler and manufacturing purposes; one exception to be noted, that of a 172-foot drilled well at Edgmont, which contains practically no incrustants, and while containing a considerable quantity of salts of the alkalies could be used in boilers. Wells from 300 feet to 500 feet deep contain a considerable residue on evaporation, consisting for the most part of salts of the alkalies, but containing also considerable quantities of calcium and magnesium. The most satisfactory water is obtained from the Mississippi river. The water obtained from many of the driven wells, especially those in the American bottoms at Poag, is of good quality.

Of the 51 waters analyzed, 14 would be condemned for excessive residue; 19 would be benefited by treatment with soda ash and passing them through a feed water heater, or by treatment with soda ash and lime and allowing the sediment to settle before the water is added to the boilers; 15 would be benefited by treatment with lime alone, and allowing the sediment to settle; and three are of sufficient purity to give very satisfactory water without treatment.

The Mineral Content of Waters—

Town	Alton	Alton	Belleville	Belleville
County	Madison	Madison	St. Clair	St. Clair
Number	2211	14649	10805	10983
Date	May 12, 1897	July 18, 1906	Dec. 17, 1902	April 4, 1903
Owner	L. F. Schussler		W. Renshaw	F. Voellinger.
Depth	80 feet	1,400 ft drilled	Surface	Spring
IONS.	Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.
Potassium	1.6			4.0
Sodium Na	15.4	5756.4	228.7	28.4
Ammonium (NH_4)		8.2		3.6
Magnesium Mg	35.7	190.4	16.7	39.7
Calcium Ca	108.6	335.2	32.4	110.8
Ferrous Fe	5.6	1.4		.9
Aluminium Al	2.1	4.4		3.6
Silica Si	12.3	14.0	5.0	10.2
Nitrite		1.2		
Nitrate NO_3	.2	.4	.9	.3
Chloride Cl	4.	9591.4	8.8	3.2
Sulphate SO_4	12.4	436.0	41.0	7.3

Hypothetical

	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.
Potassium Nitrate	.3	*.02*					.6	*.04*
Potassium Chloride	3.0	*.17*					6.7	*.39*
Potassium Sulphate							.6	*.04*
Sodium Nitrate			.5	*.03*	1.3	*.08*		
Suspended matter					99.4	*5.80*	198.8	*11.60*
Sodium Chloride	4.2	*.24*	14609.7	*852.18*	14.5	*.85*		
Sodium Sulphate	18.6	*1.08*			51.8	*3.03*	10.7	*.62*
Sodium Carbonate	18.1	*1.06*					57.5	*3.36*
Ammonium Sulphate			24.3	*1.42*				
Ammonium Carbonate							9.6	*.56*
Magnesium Chloride			744.6	*43.43*				
Magnesium Sulphate					7.5	*.44*		
Magnesium Carbonate	117.4	*6.85*			53.1	*3.10*	138.2	*8.06*
Calcium Chloride			262.1	*15.29*				
Calcium Sulphate			618.0	*36.05*				
Calcium Carbonate	272.0	*15.86*	146.5	*8.55*	96.1	*5.61*	276.8	*16.15*
Oxide of Iron and Aluminum					2.2	*.13*		
Ferrous Sulphate								
Ferrous Carbonate	11.6	*.67*	2.9	*.17*			1.9	*.11*
Alumina	4.	*.23*	4.4	*.26*			6.8	.40
Silica	26.1	*1.52*	14.0	.82	10.6	*.62*	21.8	*1.28*
Sodium Nitrite								
Bases			1.2	*.07*				
Totals	475.3	*27.70*	16428.2	*958.27*	336.5	*19.66*		

From the East St. Louis District.

Belleville.....	Belleville	Belleville..	Caseyville ...	Caseyville .	Caseyville .
St. Clair.....	St. Clair.....	St. Clair...	St. Clair.....	St. Clair...	St. Clair ...
10250..........	15017..........	....	14626 (88).....	14629(176)...	14993........
Feb. 8, 1902..	Sept. 17, 1906.	....	July 14, 1906..	July 14, 1906	Sept. 15, 1906
H. Kircher...	E. J. DuPont.	....	....	....	J. W. Mosier
425 ft	450 ft	Well 102....	25 ft dug......	40 ft. dug...	25 ft........
Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.	Milligrams per 1000 c. c.	Milligrams per 1,000 c. c.	Milligrams per 1000 c. c.	Milligrams per 1000 c. c.
....	....	....	....	....	....
139.1	217.0	374.0	207.6	151.7	92.2
....	.4	....	.1	....	.1
3.5	3.8	....	340.4	232.1	115.1
3.8	6.1	9.1	646.9	500.7	254.5
....	....	....	....	....	.1
....	....	....	....	....	2.2
4.2	21.0	21.4	13.0	16.0	66.0
....	.3	....	5.0	5.0	....
.3	.8	....	441.9	265.1	56.5
9.0	80.0	25.8	700.0	250.0	188.0
5.5	9.8	9.7	1237.3	1255.8	489.0

Combinations.

Parts per million.	Grains per U. S. gal.	Parts per million.	Grain per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	
......	......	......	......	......	......	......	......	......	......	......	......	KNO_3..........
......	......	......	......	......	......	......	......	......	......	......	......	KCl..........
......	......	......	......	......	......	......	......	......	......	......	......	K_2SO_4..........
.5	*.03*	1.0	*.06*	......	......	606.1	*35.35*	363.6	*21.2*	77.5	*4.52*	$NaNO_3$..........
......	......	......	......	......	......	......	......	......	......	......	......	$NaNO_2$..........
15.0	*.87*	132.0	*7.70*	22.6	*2.48*	100.1	*6.42*	135.0	*7.87*	180.7	*10.53*	$NaCl$..........
8.2	*.49*	14.5	*.85*	14.3	*.83*	......	......	......	......	......	......	Na_2SO_4..........
236.6	*16.71*	365.9	*21.34*	811.5	*47.33*	......	......	......	......	......	......	Na_2CO_3..........
......	......	......	......	......	......	.3	*.02*	......	......	.3	*.02*	$(NH_4)_2Cl$..........
......	......	1.1	*.06*	......	......	......	......	......	......	......	......	$(NH_4)_2CO_3$..........
......	......	......	......	......	......	850.6	*49.62*	226.0	*13.18*	105.1	*6.13*	$MgCl_2$..........
......	......	......	......	......	......	607.5	*35.44*	861.6	*50.26*	436.5	*25.45*	$MgSO_4$..........
12.2	*.71*	13.2	*.77*	......	......	......	......	......	......	......	......	$MgCO_3$..........
......	......	......	......	......	......	......	......	......	......	......	......	$CaCl_2$..........
......	......	......	......	......	......	1066.9	*62.23*	805.8	*47.0*	199.6	*11.63*	$CaSO_4$..........
8.9	*.52*	15.2	*.89*	22.7	*1.32*	830.6	*48.45*	657.5	*38.35*	488.5	*28.49*	$CaCO_3$..........
.6	*.03*	6.0	*.35*	......	......	15.0	*.87*	11.0	*.64*	......	......	$Fe_2O_3 + Al_2O_3$.
......	......	......	......	......	......	......	......	......	......	.2	*.01*	$FeSO_4$..........
......	......	......	......	......	......	......	......	......	......	......	......	$FeCO_3$..........
......	......	......	......	......	......	......	......	......	......	2.2	*.13*	Al_2O_3..........
9.0	*.52*	21.0	*1.22*	21.4	*1.25*	13.0	*.76*	16.0	*.93*	66.0	*3.84*	SiO_2..........
......	......	.5	*.03*	......	......	......	......	......	......	......	......	SiO_2 +..........
......	......	7.8	*.45*	......	......	5.0	*.29*	5.0	*.29*	8.2	*.49*	
341.0	*19.81*	578.2	*33.72*	912.5	*53.21*	4105.1	*239.45*	3081.5	*179.73*	1564.9	*91.21*	

The Mineral Content of Waters

Town	Collinsville	Collinsville	Collinsville	Collinsville
County	Madison	Madison	Madison	Madison
Number	4271	4280	10753	14529
Date	Oct. 26, 1898	Oct. 26, 1898	Nov. 10, 1902	June 22, 1906
Owner	J.R. Wadsw'th	J.R. Wadsw'th	S. E. Simpson	S. Harrison
Depth	601'	706'	90'	90'
IONS.	Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.
Potassium	27.9	18.9	2.2	1.7
Sodium Na	830.4	833.8	38.2	9.0
Ammonium (NH_4)	....	1.3	.1	.3
Magnesium Mg	17.9	19.7	27.9	43.7
Calcium Ca	38.8	31.7	74.2	82.8
Ferrous Fe	2.5	1.5	1.2	.6
Aluminium Al	4.3	.6	1.0	1.6
Silica Si	24.1	3.3	9.5	19.2
Nitrite	....	....	....	....
Nitrate NO_3	1.7	.6	.7	.2
Chloride Cl	865.0	680.0	10.3	5.0
Sulphate SO_4	450.4	505.4	16.9	41.1

Hypothetical

	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.
Potassium Nitrate	3.8	*.22*	2.8	*.16*	1.1	*.06*	.3	*.02*
Potassium Nitrite	1.1	*.06*	1.1	*.06*	....	....	....	....
Potassium Chloride	48.6	*2.83*	33.1	*1.92*	3.3	*.19*	3.0	*.17*
Sodium Nitrate	....	....	....	....	....	....	....	....
Sodium Chloride	1387.3	*80.92*	1094.7	*63.85*	14.4	*.86*	5.9	*.34*
Sodium Sulphate	666.3	*38.87*	747.6	*43.60*	25.0	*1.46*	20.7	*1.21*
Sodium Carbonate	158.2	*9.23*	485.8	*28.34*	56.2	*3.28*	....	....
Ammonium Sulphate	....	....	....	....	....	....	1.1	*.06*
Ammonium Chloride	....	....	....	....	....	....	....	....
Ammonium Carbonate	....	....	3.4	*.20*	.3	*.02*	....	....
Magnesium Chloride	....	....	....	....	....	....	....	....
Magnesium Sulphate	....	....	....	....	....	....	41.7	*2.43*
Magnesium Carbonate	62.2	*3.62*	68.5	*3.99*	97.2	*5.67*	91.1	*5.31*
Calcium Sulphate	....	....	....	....	....	....	....	....
Calcium Carbonate	97.1	*5.65*	79.7	*4.64*	185.4	*10.82*	206.7	*12.06*
Ferrous Carbonate	5.1	*.30*	3.2	*.18*	2.6	*.15*	1.2	*.07*
Alumina	8.2	*.48*	1.2	*.07*	1.9	*.11*	1.6	*.09*
Silica	51.4	*3.00*	7.1	*.40*	20.3	*1.19*	19.2	*1.12*
Bases	....	....	....	....	....	....	2.5	*.15*
Total	2489.3	*145.18*	2528.1	*147.41*	407.7	*23.81*	395.0	*23.03*

from the East St. Louis District.

Collinsville.. Madison..... 14530......... June 22, 1906 S. Harrison.. 70ft..........	Collinsville.. Madison..... 14570 .... June 29, 1906 Shallow.....	Dupo...... St. Clair .. 14675 (110).. July24, 1906 70ft driven.	East Alton.. Madison .... 14650 (189a).. July 18, 1906. 37ft driven...	East Alton Madison .. 14650 (6, 7) . July18, 1906 54ft drilled	East Alton. Madison.... 14652 (5).... July 18, 1906 35ft driven.
Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.	Milligrams per 1000 c. c.	Milligrams per 1,000 c. c.	Milligrams per 1000 c. c.	Milligrams per 1000 c. c.
2.2	....	....	....	....	....
12.6	77.1	11.3	10.	17.5	12.
....	.05	.6	.1	.1	.4
41.8	212.5	21.2	15.2	18.9	14.4
65.2	424.6	81.6	52.8	66.3	75.9
2.8	4.2	10.1	.8	.6	9.5
1.6	3.2	2.9	1.8	1.9	23.4
19.0	27.6	34.0	26.	24.3	22.1
....	2.0	.6	.6	.6	.8
3.9	88.4	.9	.7	.8	.4
5.5	220.0	2.0	8.5	22.5	16.5
51.2	931.9	.7	86.5	161.6	115.

Combinations.

Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	
5.7	.33	......	......	......	......	......	......	......	......	......	......	$K\ NO_3$ ....
......	......	......	......	......	......	......	......	......	......	......	......	$K\ NO_2$ ....
......	......	......	......	......	......	......	......	......	......	......	......	$K\ Cl$ ....
.5	.03	121.2	7.07	1.2	.07	1.0	.06	11.0	.64	.5	.03	$Na\ NO_3$ ....
9.1	.53	112.4	6.56	3.3	.19	14.0	.82	36.8	2.15	27.2	1.59	$Na\ Cl$ ....
27.4	1.60	......	......	1.0	.06	13.0	.76	......	......	3.7	.22	$Na_2\ SO_4$ ....
......	......	......	......	21.6	1.26	......	......	......	......	......	......	$Na_2\ CO_3$ ....
......	......	......	......	......	......	.4	.02	.3	......	1.5	.09	$(NH_4)_2\ SO_4$ ....
......	......	.1	.01	......	......	......	......	......	.02	......	......	$(NH_4)_2\ Cl_2$ ....
......	......	......	......	1.6	.09	......	......	......	......	......	......	$(NH_4)_2\ CO_3$ ....
......	......	204.0	11.90	......	......	......	......	......	......	......	......	$Mg\ Cl_2$ ....
41.0	2.39	792.4	46.22	......	......	75.1	4.38	93.4	5.45	71.2	4.15	$Mg\ SO_4$ ....
116.0	6.77	......	......	73.4	4.28	......	......	......	......	......	......	$Mg\ CO_3$ ....
......	......	424.1	24.74	......	......	24.8	1.45	123.4	7.20	77.4	4.53	$Ca\ SO_4$ ....
162.7	9.49	749.6	43.71	203.7	11.88	113.6	6.63	74.9	4.37	132.6	7.73	$Ca\ CO_3$ ....
5.8	.34	8.7	.51	20.9	1.22	1.7	.10	1.2	.07	19.7	1.15	$Fe\ CO_3$ ....
1.6	.09	3.2	.19	2.9	.17	1.8	.10	1.9	.11	23.4	1.36	$Al_2\ O_3$ ....
19.0	1.11	27.6	1.61	34.0	1.98	26.	1.52	24.3	1.42	22.1	1.29	$Si\ O_2$ ....
.7	.04	2.0	.12	.6	.03	.6	.03	.6	.03	.8	.05	$Si\ O_2+$ ....
389.5	22.72	2445.3	142.64	364.2	21.23	272.0	15.87	367.8	21.46	380.1	22.19	

The Mineral Content of Waters

Town	E. St. Louis	E. St. Louis	E. St. Louis	E. St. Louis
County	St. Clair	St. Clair	St. Clair	St. Clair
Number	11666	11800	11801	13939
Date	Dec. 9, 1902	Feb. 9, 1904	Feb. 9, 1904	Jan. 23, 1906
Owner	C. Hagedorn	M. R. Thayer	M. R. Thayer	....
Depth	80 ft.	90 ft.	Miss. River	Miss. River
Strata	Gravel	Sand	....	....
IONS.	Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.
Potassium	....	....	....	2.4
Sodium Na	30.7	59.2	23.2	12.2
Ammonium (NH_4)	.8	.8	.448	.2
Magnesium Mg	29.9	42.1	13.0	21.0
Calcium Ca	176.1	138.4	35.9	52 2
Ferrous Fe				.2
Aluminium Al	....	....	....	1.2
Silica Si	11.5	16.9	6.2	8.2
Nitrite	....	....	....	....
Nitrate NO_3	1.4	....	.8	3.1
Chloride Cl	28.8	43.5	5.8	7.0
Sulphate SO_4	64.1	102.7	45.6	35.5

Hypothetical

	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.
Potassium Nitrate	....	....	....	....	....	....	5.1	*.30*
Potassium Chloride	....	....	....	....	....	....	.8	*.05*
Sodium Nitrate	1.9	*.11*	....	....	1.1	*.06*	....	....
Sodium Chloride	49.5	*2.89*	71.8	*4.19*	9.6	*.56*	10.9	*.64*
Sodium Sulphate	34.6	*2.02*	95.7	*5.58*	59.1	*3.44*	24.4	*1.42*
Sodium Carbonate	....	....	....	....	....	....	....	....
Ammonium Sulphate	2.9	*.17*	2.9	*.17*	1.6	*.09*	....	....
Ammonium Carbonate	....	....	....	....	....	....	....	....
Magnesium Sulphate	48.3	*2.82*	45.0	*2.62*	5.5	*.32*	23.7	*1.38*
Magnesium Carbonate	70.4	*4.10*	114.7	*6.69*	41.3	*2.41*	56.1	*3.28*
Calcium Sulphate	....	....	....	....	....	....	....	....
Calcium Carbonate	441.0	*25.72*	345.9	*20.07*	89.8	*5.24*	130.3	*7.60*
Oxide of Iron and Aluminum	28.2	*1.35*	43.1	*2.51*	11.7	*.68*	....	....
Ferrous Carbonate	....	....	....	....	....	....	.4	*.02*
Alumina	....	....	....	....	....	....	1.1	*.07*
Silica	24.4	*1.42*	28.8	*1.68*	13.2	*.77*	8.2	*.48*
Bases	....	....	....	....	....	....	....	....
Total	696.2	*40.60*	747.9	*43.51*	232.9	*13.57*	261.1	*15.24*

from the East St. Louis District.

E. St. Louis	E. St. Louis..	E. St. Louis	E. St. Louis.	E. St. Louis	E. St. Louis
St. Clair......	St. Clair......	St. Clair....	St. Clair......	St. Clair....	St. Clair....
14619 (69).....	14620 (70)	14621 (74)...	14622 (71).....	14623 (60) ..	14624 (75)...
July 12, 1906..	July 12, 1906..	July 11, 1906	July 11, 1906..	July 11, 1906	July 11, 1906
....	....	....	....	....	....
360 ft.	450ft drilled..	140ft driven	57ft driven...	80ft driven.	120ft drilled
Rock.........	....	....	....	....	....
Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.	Milligrams per 1000 c. c.	Milligrams per 1,000 c. c.	Milligrams per 1000 c. c.	Milligrams per 1000 c. c.
....	....	....	....	....	....
149.4	40.1	17.5	24.4	14.2	58.5
.7	.4	.5	....	.5	.3
34.7	19.3	31.1	42.3	7.7	22.4
95.9	89.9	100.7	172.7	105.3	84.4
6.9	23.2	10.1	10.8	11.2	6.4
5.0	11.3	3.3	7.6	36.6	3.6
27.	32.2	37.7	29.4	35.7	35.3
2.0	.7	.9	.6	1.0	1.2
1.4	.5	.5	.5	1.1	.7
220.	32.5	5.5	13.0	15.0	5.5
86.	10.	19.0	348.3	51.1	4.6

Combinations.

Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	
......	......	......	......	......	......	......	......	......	......	......	......	K NO_3........
......	......	......	......	......	......	......	......	......	......	......	......	K Cl........
1.9	.11	.7	.04	.7	.04	.7	.04	1.5	.09	1.0	.06	Na NO_3.......
363.0	21.17	53.6	3.13	9.1	.53	21.5	1.25	24.8	1.45	9.1	.53	Na Cl........
18.2	1.06	14.8	.86	28.1	1.64	48.4	2.82	12.3	.72	6.8	.40	Na_2 SO_4.......
......	......	32.2	1.88	10.6	.62	......	......	......	......	120.6	7.03	Na_2 CO_3.......
2.6	.15	......	......	......	......	......	......	1.8	.10	......	......	$(NH_4)_2$ SO_4....
......	......	1.1	.06	1.3	.08	......	......	......	......	.8	.05	$(NH_4)_2$ CO_3....
90.0	5.25	......	......	......	......	209.1	12.20	38.1	2.22	......	......	Mg SO_4.......
57.1	3.33	66.8	3.90	107.7	6.28	......	......	......	......	77.6	4.53	Mg CO_3.......
......	......	......	......	......	......	225.1	13.13	15.7	.92	......	......	Ca SO_4.......
239.4	13.96	224.4	13.09	251.4	14.66	265.6	15.49	251.4	14.66	210.7	12.29	Ca CO_3........
......	......	......	......	......	......	......	......	......	......	......	......	Fe_2 O_3+Al_2 O_3.
14.3	.83	48.1	2.81	20.9	1.22	22.4	1.31	23.2	1.35	13.3	.78	Fe CO_3........
5.	.29	11.3	.66	3.3	.19	7.6	.44	36.6	2.13	3.6	.21	Al_2 O_3........
27.	1.57	32.2	1.88	37.7	2.20	29.4	1.71	35.7	2.08	35.3	2.06	Si O_2.........
2.	.12	.7	.04	.9	.05	.6	.03	1.0	.06	1.2	.07	Si O_2+ ....
820.5	47.84	485.9	28.35	471.7	27.51	830.4	48.42	442.1	25.78	480.0	28.01	

The Mineral Content of Waters

Town	E. St. Louis.	E. St. Louis	Edgemont	Eddwardville
County	St. Clair	St. Clair	St. Clair	Madison
Number	14677 (63)	55	14569	15372
Date	July 23, 1906	....	June 28, 1906	Nov. 21, 1906
Owner	....	....	....	....
Depth	450ft drilled	....	782ft drilled	Unknown

IONS.	Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.
Potassium	....	....	5.2	....
Sodium Na	72.0	31.2	246.4	12.4
Ammonium (NH_4)	.6	.8	....	.1
Magnesium Mg	29.1	29.9	2.4	28.5
Calcium Ca	83.1	176.3	12.7	41.2
Ferrous Fe	1.1	....	4.2	.4
Aluminum Al	2.8	....	2.9	1.8
Silica Si	30.3	24.3	11.2	14.3
Nitrite	.3	....	.5	....
Nitrate NO_3	1.4	1.4	.4	11.5
Chloride Cl	66.0	30.0	91.5	7.0
Sulphate SO_4	17.9	64.0	38.6	45.3

Hypothetical

	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.
Potassium Nitrate	....	....	....	....	.7	*.04*	....	....
Potassium Chloride	....	....	....	....	9.3	*.54*	....	....
Sodium Nitrate	1.9	*.11*	1.9	*.11*	....	....	15.8	*.92*
Sodium Chloride	108.9	*6.35*	49.5	*2.89*	143.7	*8.38*	11.6	*.68*
Sodium Sulphate	26.5	*1.55*	34.5	*2.02*	57.1	*3.33*	10.8	*.63*
Sodium Carbonate	46.0	*2.68*	....	....	394.3	*23.00*	....	....
Ammonium Sulphate	....	....	2.9	*.17*	....	....	.4	*.02*
Ammonium Carbonate	1.6	*.09*	....	....	....	....	....	....
Magnesium Sulphate	....	....	48.3	*2.82*	....	....	47.2	*2.75*
Magnesium Carbonate	100.8	*5.88*	70.2	*4.10*	8.3	*.48*	65.8	*3.84*
Calcium Sulphate	....	....	....	....	....	....	....	....
Calcium Carbonate	207.4	*12.10*	440.2	*25.72*	31.7	*1.85*	102.8	*6.00*
Oxide of Iron and Aluminum	....	....	23.1	*1.32*	....	....	....	....
Ferrous Carbonate	2.3	*.13*	....	....	8.7	*.51*	.8	*.05*
Alumina	2.8	*.16*	....	....	2.9	*.17*	1.8	*.10*
Silica	30.3	*1.77*	24.3	*1.42*	11.2	*.65*	14.3	*.83*
Bases	.3	*.02*	....	....	.5	*.03*	2.3	*.13*
Total	528.8	*30.84*	694.9	*40.60*	668.4	*38.98*	273.6	*15.95*

from the East St. Louis District.

Falling Sprg	Falling Sprg	Granite Cy	Granite City	Granite Cy	Granite Cy
St. Clair.....	St. Clair.....	Madison ..	Madison.....	Madison...	Madison....
14571.........	14676.........	41.........	41...	41.........	42.........
June 25, 1906	July 23, 1906.	....	....	....	....
....	....	....	....	....	....
Spring.......	Spring.......	....	....	....	....
Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.	Milligrams per 1000 c. c	Milligrams per 1,000 c. c.	Milligrams per 1000 c. c	Milligrams per 1000 c. c.
....	....	....	....	....	....
10.2	20.5	40.1	11.7	11.7	24.3
.1	.2	....	....	....	....
11.0	24.5	....	29.2	29.1	31.7
35.7	90.8	142.2	112.6	112.6	131.4
.8	1.7	....	....	....	....
1.6	5.7	....	....	....	....
12.4	57.1	115.7	26.4	26.4	25.6
....	5.1	....	....	....	....
.7	.4	....	....	....	....
7.5	10.0	....	18.0	18.0	30.8
11.5	14.8	84.6	101.4	101.5	222.4

Combinations.

Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	
....	......	....	......	......	......	....	......	......	......	......	......	$K\ NO_3$........
....	......	....	......	......	......	....	......	......	......	......	......	$K\ Cl$..........
1.0	*.06*	.5	*.03*	......	......	....	......	......	......	......	......	$Na\ NO_3$........
12.4	*.72*	16.5	*.96*	......	......	29.7	*1.73*	29.7	*1.73*	50.8	*2.96*	$Na\ Cl$........
15.4	*.90*	21.9	*1.28*	123.7	*7.21*	....	......	......	......	13.3	*.78*	$Na_2\ SO_4$........
....	......	15.7	*.92*	......	......	....	......	......	......	......	......	$Na_2\ CO_3$........
.4	*.02*	....	......	......	......	....	......	......	......	......	......	$(NH_4)_2\ SO_4$....
....	......	.5	*.03*	......	......	....	......	......	......	......	......	$(NH_4)_2\ CO_3$....
1.0	*.06*	....	......	......	......	127.1	*7.41*	127.2	*7.42*	156.7	*9.14*	$Mg\ SO_4$........
37.4	*2.18*	84.8	*4.95*	......	......	12.1	*.71*	11.8	*.69*	......	......	$Mg\ CO_3$........
....	......	....	......	1.4	*.08*	....	......	......	......	125.3	*7.31*	$Ca\ SO_4$........
89.1	*5.20*	226.7	*13.22*	354.0	*20.65*	281.1	*16.40*	281.1	*16.40*	235.9	*13.76*	$Ca\ CO_3$........
....	......	....	......	30.8	*1.80*	11.6	*.68*	11.6	*.68*	9.3	*.54*	$Fe_2\ O_3 + Al_2\ O_3$.
1.7	*.10*	3.5	*.20*	......	......	....	......	......	......	......	......	$Fe\ CO_3$........
1.6	*.09*	5.7	*.33*	......	......	....	......	......	......	......	......	$Al_2\ O_3$........
12.4	*.72*	57.1	*3.33*	115.7	*6.76*	26.4	*1.54*	26.4	*1.54*	25.6	*1.49*	$Si\ O_2$........
....	......	5.1	*.30*	......	......	....	......	......	......	......	......	$Si\ O_2+$........
172.4	*10.05*	538.0	*25.55*	625.6	*36.50*	488.0	*28.47*	487.8	*28.46*	616.9	*35.98*	

The Mineral Content of Waters

Town	Granite City	Madison	Madison	Madison
County	Madison	Madison	Madison	Madison
Number	45	Deep well	Pond water	46
Date				
Owner				
Depth				

IONS.	Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.
Potassium				
Sodium Na	41.0	13.0	22.0	11.4
Ammonium (NH_4)				
Magnesium Mg	22.7	26.6	29.6	33.6
Calcium Ca	97.2	102.3	64.4	94.6
Ferrous Fe				
Aluminium Al				
Silica Si	29.4	31.8	25.0	39.8
Bromine Br				
Nitrate NO_3				
Chloride Cl	9.9	19.9	13.9	17.5
Sulphate SO_4	82.7	66.2	123.8	54.3
Iodine I				

Hypothetical

	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.
Potassium Nitrate								
Potassium Sulphate								
Potassium Carbonate								
Sodium Bromide								
Sodium Iodine								
Sodium Nitrate								
Sodium Chloride	16.4	*.96*	32.9	*1.92*	22.9	*1.34*	28.9	*1.69*
Sodium Sulphate	106.4	*6.21*			40.1	*2.34*		
Sodium Carbonate								
Ammonium Sulphate								
Ammonium Carbonate								
Magnesium Chloride								
Magnesium Sulphate	13.5	*.79*	83.0	*4.84*	121.2	*7.07*	68.1	*3.97*
Magnesium Carbonate	69.3	*4.04*	37.4	*2.18*	17.7	*1.03*	68.8	*4.00*
Calcium Carbonate	242.6	*14.15*	255.4	*14.90*	160.8	*9.38*	236.1	*13.77*
Oxide of Iron and Aluminium	29.4	*1.71*	14.9	*.87*	13.0	*.76*	26.9	*1.57*
Ferrous Carbonate								
Alumina								
Silica	29.4	*1.71*	31.8	*1.85*	25.0	*1.46*	39.8	*2.32*
Bases								
Total	507.0	*29.57*	455.4	*26.56*	400.7	*23.38*	468.4	*27.32*

from the East St. Louis District.

Mascoutah..... St. Clair........ 193............. .... Post'lNal'g Co	O'Fallon .... St. Clair..... 14627 (129a–c) July 13, 1906. .... 40' driven....	O'Fallon .. St. Clair... 14628 (130). July13, 1906 .... 40' dug.....	Poag .... Madison..... 3280.......... Feb. 18, 1898. C.Boeschst'n 55'...........	Poag ...... Madison... 15373 (9)... Nov.19,1906 .... Wells......	Stolle ...... St. Clair.... 14674 (108).. .... Spring..... ....
Milligrams per 1,000 c. c.	Milligrams per 1,000 c. c.	Milligrams per 1000 c. c	Milligrams per 1,000 c. c.	Milligrams per 1000 c. c	Milligrams per 1000 c. c
137.6	....	....	1.6	11.1	....
7445.6	13.0	13.0	5.9	11.1	15.6
....	.4	.2	....	.1	....
276.6	35.2	39.0	6.6	17.9	29.4
778.9	135.7	93.9	29.7	52.9	98.4
1.5	1.1	1.9	.8	.6	1.6
....	2.1	1.9	.14	2.6	29.5
....	22.7	21.1	....	8.5	48.4
36.5	....	.3	....	....	....
....	1.2	1.2	15.9	11.5	2.5
10,925.4	3.5	6.0	2.8	7.0	6.0
822.4	19·3	22.0	14.1	49.1	18.7
6.7	....	....	....	....	....

Combinations.

Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	Parts per million.	Grains per U. S. gal.	
....	....	....	......	......	......	4.3	*.25*	......	......	......	......	$K\ NO_3$.......
243.9	*14.23*	....	......	......	......	....	......	......	......	......	......	$K_2\ SO_4$.......
49.6	*2.89*	....	......	......	......	....	......	......	......	......	......	$K_2\ CO_3$.......
46.9	*2.74*	....	......	......	......	....	......	......	......	......	......	Na Br.......
7.9	*.46*	....	......	......	......	....	......	......	......	......	......	Na I........
....	....	1.6	*.09*	1.6	*.09*	18.3	*1.06*	15.8	*.92*	3.4	*.20*	$Na\ NO_3$......
18029.2	*1051.64*	5.8	*.34*	9.9	*.58*	2.5	*.14*	11.6	*.67*	9.9	*.58*	Na Cl.......
1018.2	*59.39*	28.6	*1.67*	26.8	*1.56*	....	......	6.8	*.40*	27.7	*1.62*	$Na_2\ SO_4$......
....	....	2.3	*.13*	......	......	....	......	......	......	4.1	*.24*	$Na_2\ CO_3$......
....	....	....	......	.7	*.04*	....	......	.4	*.02*	......	......	$(NH_4)_2\ SO_4$...
....	....	1.1	*.06*	......	......	....	......	......	......	......	......	$(NH_4)_2\ CO_3$...
....	....	....	......	......	......	3.5	*.20*	......	......	......	......	$Mg\ Cl_2$.......
....	....	....	......	4.3	*.25*	25.7	*1.50*	55.4	*3.21*	......	......	$Mg\ SO_4$.......
957.9	*55.87*	121.9	*7.11*	131.9	*7.69*	1.8	*.10*	23.2	*1.35*	101.8	*5.94*	$Mg\ CO_3$......
1944.3	*113.41*	338.7	*19.76*	234.4	*13.67*	74.3	*4.33*	131.1	*7.69*	245.6	*14.34*	$Ca\ CO_3$.......
....	....	....	......	......	......	....	......	......	......	......	......	$Fe_2\ O_3 + Al_2\ O_3$.
3.1	*.18*	2.3	*.13*	3.9	*.23*	.2	*.01*	1.2	*.07*	3.3	*.19*	$Fe\ CO_3$.......
....	....	2.1	*.12*	1.9	*.11*	.3	*.02*	2.6	*.15*	29.5	*1.72*	$Al_2\ O_3$........
....	....	22.7	*1.32*	21.1	*1.23*	30.0	*1.75*	8.5	*.50*	48.4	*2.82*	$Si\ O_2$........
....	....	....	......	.3	*.02*	....	......	3.3	*.19*	8.1	*.47*	$Si\ O_2 +$.......
22301.0	*1300.81*	527.1	*30.73*	436.8	*25.47*	160.6	*9.36*	259.9	*15.17*	481.8	*28.12*	

The Mineral Content of Waters from the East St. Louis District.

Town	Mascoutah	
County	St. Clair	
IONS.	Milligrams per 1,000 c. c.	
Sodium Na	4,684.3	
Magnesium Mg	450.6	
Calcium Ca	2,805.6	
Ferrous Fe	9.1	
Silica Si	2.704.9	
Chloride Cl	11,489.0	

Hypothetical Combinations.

	Parts per million.	Grains per U. S. gal.	
Sodium Chloride	11888.6	*693.46*	Na Cl
Magnesium Chloride	1762.0	*102.78*	$Mg\ Cl_2$
Calcium Chloride	4653.2	*271.42*	$Ca\ Cl_2$
Calcium Sulphate	3820.7	*222.86*	$Ca\ SO_4$
Ferrous Carbonate	13.0	*.76*	$Fe\ CO_3$
Total	22137.5	*1291.28*	

Sanitary Analyses.

The following table shows the sanitary analyses of waters from the East St. Louis district that have been sent to the State Water Survey for analysis. The greater number of these waters have been sent to the survey because of suspected contamination and therefore are hardly representative of the normal waters of the district. A number of analyses of municipal supplies have been made. Some of these were for the purpose of determining the best available source of supply, as for example, when the location of the wells of the Edwardsville Water Company were being considered, many analyses were made of proposed sources of supply.

Sanitary Analyses of Water from the East St. Louis District.

Serial number.	City or Town.	Source of water.	Date of collection.	Appearance. Turbidity.	Appearance. Color.	Appearance. Odor.	Total residue on evaporation.	Chlorine in Chlorides.	Consumed oxygen.	Nitrogen as— Ammonia. Free.	Nitrogen as— Ammonia. Albuminoid.	Nitrogen as— Nitrites	Nitrogen as— Nitrates.	Alkalinity.
2832	Alton, M	River	Oct. 20, 1897	Dec	Mud	00	280.1	10.	12.1	.020	.360	.017	.300	......
5974	M	..do..	Sept. 28, 1899	Dis	.30	00	174.8	7 0	8.75	.010	.240	.000	.160	......
15308	(1) M	..do.	Nov. 4, 1906	Dec	.6	00	224.	10.0	6.85	.032	.192	.001	.480	157.4
15309	(2) M	..do.	Nov. 5, 1906	Cle.	.2	00	202.	10.0	5.25	.024	.128	.004	.440	144.0
51	I	12 ft.*	Oct. 9, 1895	......	......	......	508.3	15.0	2.2	.284	.068	.000	.000	......
1964	I	River	Mar. 2, 1897	Sli.	.08	00	249.2	2.8	4.7	.004	.320	.018	2.400	......
2211	I	80†	May 12, 1897	Dis.	Yellow	00	414.	4.	1.5	.400	.018	.000	.040	......
14387	I	Spring	May 17, 1906	Dec	.2	00	469.	10.	2.45	.040	.120	.000	1.040	297.0
14649	I	1,400†	July 17, 1906	Sli	.2	00	16,257.	10,500.	30.5	6.400	.112	.000	.080	163.0
1450	Belleville, M	Reservoir	Oct. 6, 1896	Con	.7	00	176.8	3.8	7.5	036	.440	.032	.700	......
1456	M	..do.	Oct. 2, 1896	Sli.	.02	00	139.6	3.2	4.8	.024	.288	.000	.150	......
4905	M	500-1500†	April 5, 1899	..do.	.02	00	376.	19.	1.6	.004	.030	.000	.300	......
5228	M	..do.	June 14, 1899	..do.	.20	00	352.8	16.	2.4	.000	.080	.000	.560	......
5324	M	..do.	June 30, 1899	..do.	.02	00	412.8	36.	1.6	.090	.050	.038	.160	......
5325	M	Reservoir	..do.	Dis.	.04	00	330 8	17.5	2.75	.016	.094	.072	.320	......
5326	M	500-1500†	..do.	..do.	.05	00	334.4	17.	2.55	.010	.068	.011	.280	......
13648	M	..do.	Oct. 6, 1905	......	......	......	324.	19.	2.1	.024	.114	.000	.400	......
13800	M	..do.	Dec. 4, 1905	Cle.	.00	2 ear	417.	18.	2.05	.052	.026	.001	.28	323.4
13801	M	..do.	..do.	..do.	.00	..do.	424.	17.5	1.45	.124	.126	.007	.24	315.6
13802	M	..do.	Nov. 4, 1905	Fnt	.00	2 mus	435.	18.0	2.0	.056	.094	.017	.160	......
14755	M	..do.	Aug. 10, 1906	Cle.	.00	00	425.	17.0	1.05	.034	.064	.003	.280	325.9
14756	M	..do.	..do.	..do.	.00	00	426.	19.	1.7	.006	.060	.000	.44	328.0
14757	M	..do.	..do.	..do.	.00	00	439.	19.5	1.65	.026	.068	.000	.280	331.0
14758	M	..do.	..do.	..do.	.00	Kero	425.	20.	2.0	.028	.090	.019	.28	324.0
895	I	23 flowing	May 25, 1896	......	......	......	1,786.	221.	3.2	.946	.244	.060	.300	......
1457	I	Lake	Oct. 3, 1896	Sli	.02	00	148.	3.3	25.6	.030	.284	.009	.150	......
2509	I	Well	July 29, 1897	Dis.	.2	00	437.2	51.0	5.0	2.000	.142	.000	.050	......
3154	I	42*	Jan. 10, 1898	V Sli	.01	00	401.6	10.	.9	.001	.026	.000	5.00	......
3155	I	20*	..do.	..do.	.01	00	436.4	28.	1.1	9.000	.020	.000	13.500	......
3507	I	35*	April 27, 1898	..do.	.01	00	838.4	160.	1.8	.001	.016	.001	8.000	......
4906	I	Unknown	April 5, 1899	Sli	.03	00	56.8	1.	4.5	.016	.112	.000	.150	......

5227	I	Well	June 14, 1899	..do.	Cle	00	1,434.4	60.	1.6	.001	.048	.001	64.000	......
6419	I	20*	Nov. 29, 1899	..do.	.02	00	492.4	7.	1 5	.004	.040	.000	.120	......
10250	I	425†	Feb. 7, 1902	Cle	.01	00	384.	9.0	2 0	.336	.032	.000	.080	......
10983	I	Spring	April 4, 1903	Dec	Red	DV	704.	3.2	25.6	2.800	.464	.004	.076	......
11116	I	..do.	May 30, 1903	..do.	..do.	00	553.6	2.8	13.1	2.88	.262	.000	.120	......
11117	I	..do.	May 20, 1903	..do.	..do.	Fish	658.	3.00	17.6	2.4	.656	.000	.120	......
12791	I	38*	Dec. 29, 1904	......	......	......	630.8	68.5	1.6	......	......	.006	......	......
13641	I	40*	Oct. 6, 1905	None	.00	00	1,972.	147.5	3.6	.022	.084	.001	31.200	......
13642	I	36*	..do.	..do.	.00	00	986.	85.0	4.3	.050	.096	.054	11.60	......
13643	I	30*	..do.	Sli	.00	Ear	2,952.	220.0	6.0	.040	.114	.028	104.000	......
13644	I	25*	..do.	..do.	.00	Putr	629.	82.0	3.5	.040	.082	.006	2.00	......
13645	I	30*	..do.	..do.	.00	..do.	2,357.	305.0	4.0	.012	.146	.006	44.00	......
13647	I	30*	..do.	.60	.00	000	1,543.	145.5	4.8	.052	.092	.150	32.00	......
13649	I	35*	..do.	.00	.00	00	1,475.	160.0	4.35	.008	.062	.002	37.00	......
13650	I	40*	..do.	V sli	.00	Ear	912.	87.0	2.65	.032	.106	.000	38.00	......
13651	I	30*	..do.	.20	.00	Putr	434.	370.0	5.75	.034	.068	.034	17 00	......
13652	I	27*	..do.	.00	.00	00	340.	18.5	2.0	.036	.062	.000	6.68	......
14754	I	35*	Aug. 10, 1906	Cle	.00	00	2,668.	295.	4.8	.024	.118	.003	46.00	310.4
15017	I	450†	Sept. 17, 1906	Dist	.00	00	611.	80.	4.8	.336	.016	.104	.176	397.4
15052	I	Unknown	Sept. 25, 1906	Cle	.000	00	2,634.	315.	5.55	.330	.084	.003	69.997	345.6
15053	I	Well	..do.	..do.	.000	00	1,800.	278.	4.6	.008	.032	.003	58.0	276.5
15054	I	..do.	..do.	..do.	.000	00	1,927.	278.	4.05	.030	.052	.026	51.97	299.5
15055	I	..do.	..do.	..do.	.00	00	1,490.	159.	3.45	.032	.044	.017	16.00	311.0
14626	Caseyville, I	25*	July 13, 1906	Dist	.4	000	4,943.	700.	7.6	.056	.152	.020	100.00	341.
14629	I	40*	..do.	Cle	.1	00	3,643.	250.	4.05	.024	.096	.024	60.00	312.0
14993	I	25*	Sept. 26, 1899	V sli	.00	00	1,661.	188.	3.65	.096	.104	.170	12.83	343.6
4271	Collinsville, M	601†	Oct. 28, 1898	Fnt	.03	00	2,608.0	865.	4.7	.024	.044	.215	.400	......
10753	M	..do.	Nov. 10, 1902	Dist	.4	00	329.2	10.25	1.3	.048	.040	.000	.16	......
14529	(3) M	90†	June 18, 1906	..do.	.3	00	405.	5.0	1.8	.216	.116	.001	.039	298.8
14530	(4) M	70†	June 22, 1906	..do.	.2	00	464.	5.5	2.05	.024	.136	.003	.877	337.
2762	I	28*	Oct. 5, 1897	Sli	.03	00	295.2	13.	1.5	.004	.042	.002	1.600	......
4280	I	701†	Oct. 27, 1898	..do.	.03	00	2,544.8	680.	3 3	1.00	.030	.21	.400	......
6491	I	40†	Dec. 7, 1899	..do.	.01	00	513.2	28.	.5	.003	.030	.000	10.8	......
6919	I	47*	Feb. 14, 1900	..do.	.02	00	503.2	47.	2.4	.086	.090	.007	1.28	......
10748	I	Well*	Nov. 10, 1902	..do.	.10	00	2,400.	263.	7.8	.276	.182	2.500	59.5	......
10749	I	..do.	..do.	V sli	.00	00	2,206.4	215.	2.0	.022	.054	.000	20.00	......
10750	I	..do.	..do.	Dec	Yel	(0	263.6	9.00	5.0	.200	.202	.000	.160	......
10751	I	50*	..do.	Sli	.000	00	1,957.6	119.0	2.6	.012	.080	.000	80.00	......
10752	I	40*	..do.	V sli	.000	00	706.8	32.0	2.4	.004	.046	.001	4.00	......
14570	I	Well*	June 28, 1906	Cle	.000	00	2,785.	220.	5.40	.040	.128	.005	20.00	378.3
14859	(5) I	75*	Aug. 29, 1906	..do.	.000	00	1,566.	180.	3.2	.006	.042	.003	9.0	299.6
14675	Dupo, I	70†	July 23, 1906	Decid	.4	00	327.	2.0	2.4	.480	.056	trace.	.200	294.9
14650	East Alton, I	37†	July 17, 1906	Clear	.2	00	202	8.5	4.25	.096	.152	.001	.16	94.0
14651	I	54†	..do.	..do.	.1	00	372.	22.5	1.95	.080	.056	.006	1.800	101.0
14652	I	35†	..do.	Decid	1.2	00	410.	16.5	3.00	.280	.088	.010	.060	174.6
11801	E. St. Louis, M	River	Feb. 7, 1904	Slight	.00	00	196.	5.8	9.3	.448	.192	.008	.672	......
13939	M	..do.	Jan. 24, 1906	......	.1	Ear	239.0	7.0	6.0	.160	.160	.016	.704	153.0
11665	I	80†	Dec. 8, 1903	Decid	Yel	00	536.0	62.0	4.2	.512	.064	.000	.040	......
11666	I	..do.	..do.	..do.	..do.	00	554.0	29.	4.0	.556	.082	.012	.308	......
11667	I	..do.	..do.	..do.	..do.	00	424.4	12.0	5.4	.800	.140	.000	.040	......

Analysis of Water—Continued.

Serial number.	City or Town.	Source of water.	Date of collection.	Appearance.			Total residue on evaporation.	Chlorine in Chlorides.	Consumed oxygen.	Nitrogen as— Ammonia				Alkalinity.
				Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.	
	E. St Louis—Continued.													
11788	....	Cave	Jan. 31, 1904	Dist	Mud	Pecu	321.2	7.9	2.2	.018	.054	.001	4.00	......
11800	I	90†	Feb. 9, 1904	Sli	.00	00	680.4	43.5	3.7	.656	.054	.003	.077	......
14619	I	360†	July 11, 1906	Decid	1.6	00	853.	220.0	4.05	.576	.112	.011	.320	347.2
14620	I	450†	..do	..do	1.4	Musty	510.	32.5	4.25	.288	.144	.006	.120	345.3
14621	I	140†	..do	..do	1.2	00	474.	5.5	4.5	.360	.128	.008	.12	384.1
14622	I	57†	..do	..do	1.2	Oily	856.	13.0	2.6	.032	.080	.004	.12	271.6
14623	I	80†	..do	..do	1.1	00	464.	15.0	3.85	.360	.160	.001	.24	312.
14624	I	120†	..do	Dist	3.4	00	619.	5.5	16.0	.224	.160	.001	.160	413.2
14677	I	450†	July 23, 1906	..do	.3	00	522.	66.0	4.0	.440	.040	.001	.32	405.5
14569	Edgemont, I	782†	June 28, 1906	..do	3.	00	670.	91.5	4.7	......	......	.044	.080	390.0
2891	M	55†	Nov. 3, 1897	....	.04	Mold	138.0	2.1	4.6	.004	.056	2.2	1.0	......
2973	M	50†	Nov. 21, 1897	V sli	.02	000	160.	3.2	1.0	.001	.014	.033	6.25	......
3044	Edwardsville, M	55†	Dec. 10, 1897	Clear	.02	00	154.	2.9	1.1	.002	.024	.023	3.6	......
3045	M	..do	Dec. 9, 1897	..do	.02	00	157.6	2.9	1.2	.002	.004	.014	3.600	......
3061	M	..do	Dec. 13, 1897	..do	.02	00	152.0	2.9	.9	.001	.014	.014	3.600	......
3200	M	42†	Jan. 21, 1898	Sli	....	....	....	2.0	....	......	......	.002	1.00	......
3202	M	75†	..do	..do	....	00	....	4.0	....	......	......	.085	1 800	......
3261	M	55†	Feb. 14, 1898	V sli	.02	00	154.	2.7	1.1	.000	.001	.003	3.400	......
3287	M	..do	Feb. 18, 1898	..do	.02	00	154.8	2.9	.9	.000	.012	.002	3.400	......
4960	M	..do	April 25, 1899	Sli	.07	00	153.6	3.2	1.1	.001	.030	.016	2.800	......
4961	M	..do	..do	..do	.09	00	164.4	3.2	1.3	.002	.030	.160	2.75	......
14863	M	..do	Aug. 28, 1906	Clear	.00	00	277.	7.5	2.35	.012	.050	.200	1.120	157.1
15373	M	..do	Nov. 19, 1906	Sli	.2	00	1,025.	7.	1.30	.080	.040	.003	2.64	163.2
1264	I	74†	Aug. 10, 1896	Consid	.03	00	662.	17.	8.8	1.36	.280	.000	.16	......
1454	I	35†	Oct. 6, 1896	None	.00	00	139.2	1.6	.8	.000	.004	.009	4.000	......
1455	I	..do	..do	..do	.00	00	140.8	1.7	.6	.000	.006	.008	4.00	......
2271	I	Pond	May 27, 1897	Sli	.2	00	670.	90.	8.3	.64	.48	1.125	2.600	......
2339	I	..do	June 17, 1897	Dist	Mud	000	770.4	88.0	12.9	1.840	.720	1.550	1.000	......
2731	I	Shaft, 90 feet	Sept. 29, 1897	Sli	.04	000	1,264.8	18.0	8.0	.095	.454	.000	.400	......
2781	I	6*	Oct. 12, 1897	Dist	.1	00	151.2	2.7	9.4	.008	.240	.000	.125	......
2782	I	..do	..do	..do	.1	00	430.	4.4	8.9	1.04	.320	.000	.050	......
2974	I	Shaft, 90 feet	Nov. 22, 1897	Decid	Yel	00	978.2	19.	2.10	.560	.034	.000	.35	......

3201	I	35*	Jan. 21, 1898	Sli			00		91.0				.016	15.000	
3224	I	..do	Feb. 7, 1898	V sli		.00	00	593.2	99.0	1.50	.002	.024	.003	22 00	
3236	I	70†	..do	..do		.01	00	194.	13.0	1.100	1.002	.026	.105	.410	
4958	I	18*	April 25, 1899	Slight		.02	00	236.	5.2	1.200	.001	.028	.000	12.5	
4959	I	27*	..do	..do		.01	00	608.8	53.	1.90	.006	.028	.008	31.000	
8430	I	85†	Sept. 10, 1900	Clear		.01	00	381.2	13.	2.00	.028	.114	.000	4.000	
8946	I	86†	Jan. 10, 1901	Sli		.05	00	460.4	11.	5.30	.008	.144	.001	3.200	
13842	I	45*	Dec. 14, 1905	Cle		.1	3 Ear	1,384.0	159.	4.90	.030	.074	.004	37.000	353.6
13943	I	Creek	Jan. 24, 1906	V decid	Mud		4 Ear	813.	2.0					.640	56.1
14314	I	24*	May 7, 1906	Cle		.00	3 Ear	2,141.	157.0	3.15	.028	.120	.021	.600	124.
14663	I	37*	July 23, 1906	None		.1	000	503.	4.0	1.5	.048	.124	.004	3.76	329.8
14864	I	30*	Aug. 28, 1906	Cle		.00	00	357.	7.5	2.3	.002	.030	.001	5.280	248.3
15123	I	29*	Oct. 8, 1906	..do		.00	00	1,364.	1.53	3.2	.018	.064	.013	46.087	245.8
15295	I	Spring	Nov. 5, 1906	V dec	Mud		00	1,366.	1.0	15.7	1.600	.752	.000	7.00	316.8
15296	I	40*	..do 1905	V sli		.2	00	735.	89.0	4.3	.084	.112	.060	22.93	403.2
15372	I	Unknown	Nov. 21, 1906	Sli		.2	2 Ear	284.	7 0	3.9	.080	.048	.002	2.64	159.4
14571	Falling Springs	Spring	June 25, 1906	V dec		.3	Mud	825.	7.5		.070	1.440	.000	.16	83.4
14676		..do	July 23, 1906	Dist		.2	00	398.	10.0	3.0	.160	.080	.000	1.00	327.9
8030	Mitchell	27*	July 25, 1900	V sli		.01	00	782.0	14.	1.9	.004	.072	.048	14.4	
14627	O'Fallon, M.	40†	July 13, 1906	Dist		.4	00	396.	3.5	2.1	.320	.040	.002	.28	347.2
14628	M	40*	..do	..do		.4	00	328.	6.0	2.15	.120	.056	.010	.280	378.3
2011	I	40†	Mar. 15, 1897	Sli		.2	00	413.2	3.	1.2	.280	.024	.004	.100	
2012	I	53†	..do	..do		.02	00	673.2	72.	.9	.008	.026	.003	26.000	
2795	I	Well	Oct. 13, 1897	..do		.03	00	343.	25.5	2.25	.004	.056	.001	3.500	
2796	I	28*	..do	V sli		.02	00	786.	78.5	2.85	.004	.024	.027	12.00	
3280	Poag, M	55†	Feb. 17, 1898	..do		.02	00	153.2	2.8	.80	.001	.012	.002	3.600	
11556	Stookey, I	200†	Nov. 3, 1903	V dec	Mud		Kero	4,111.6	6.1	46.9	9.200	.720	.000	.160	
11557	I	..do	..do	Dec	Red		..do	723.6	8.0	15.5	8.200	.476	.001	.120	
14674	Stolle, I	Spring	July 23, 1906	Dist		2	Musty	426.	6.	2.35	.024	.040	.000	.560	201.6
12654	Upper Alton, M	River	Nov. 11, 1904	..do		.6	000	196.4	9.	8.00	.040	.240	.000	.44	
14941	M	..do	Sept. 10, 1906	..do		.4	000	262.0	9.0	4.4	.032	.152	.000	.560	138.2
14958	M	..do	..do	Dec		.2	000	238.0	9.5	5.7	.012	.176	.000	1.04	134.4
15030	M	..do	Sept. 24, 1906	..do	Mud		000	248.	9.0	6.6	.024	.216	.000	1.36	147.8
15031	M	..do	..do	..do	..do		000	263.	9.0	6.5	.024	.224	.000	.400	165.1
12257	I	40*	July 20, 1904	Clear			000	498.4	29.5	1.6	.014	.030	.004	20.00	
12653	I	..do	Nov. 11, 1904	..do		000	000	711.2	131.	1.	.012	.020	.017	12.40	
14940	I	..do	Sept. 10, 1906	..do		000	000	1,015.0	234.0	1.25	.016	.066	.008	2.712	278.4
14959	I	35*	..do	..do		000	000	612.	32.0	1.6	.008	.062	.010	5.11	412.8
15239	I	30*	Oct. 25, 1906	..do		000	000	524.	30.	2.05	.054	.064	.004	9.00	259.2

"M" denotes a general municipal water supply. These are placed at the head of the list of analyses from each city.
"I" denotes waters from individual sources of supply.
* under the column headed "Source of Water" denotes "dug well" after figures denoting the depth.
† under the column headed "Source of Water" denotes "driven, drilled or bored well" after figures denoting the depth.
(1) 4,600 bacteria per c. c. Colon bacillus + in 10 c. c. — in 1 c. c.
(2) 800 bacteria per c. c. Coli absent.
(3) 90,000 bacteria per c. c. Coli absent.
(4) 26,000 bacteria per c. c. Coli absent.
(5) 970 bacteria per c. c. Coli absent.

WELL SECTIONS AND MISCELLANEOUS.

In the following pages will be found well sections and other data which it was not possible to include in the well tabulations, or in the body of the text. Some of these facts are likely to be of interest to readers and of value to future investigators. It seems advisable, therefore, to include them here as they will be much more serviceable in printed form than in the note books of the survey. Where no additional data were obtained the well number is omitted. Numbers which appear on the map (plate 4) are also omitted where they stand for a location referred to in the text, and not for a well as commonly.

Table Showing Location and Character of Wells of the East St. Louis Area.

Number.	Owner.	Location.	Year.	Class.	Depth.	Diameter.	Head.	Use.	Yield.
1a	Harry L. Meyer	T. 5 N., R. 10 W	1900	Dug	55'	5'	4	Stock	12 bbl per hour
1b	Anton Reck	T. 5 N., R. 10 W	1876	do	104'	4'	50'	Park, stock	
2a	Luer Bros	do	1893	do	20'	10'	14-16'	Cooling	
2b	Alton Packing Co	do	1894	Drilled	1,400'+	3"	Flows	do	
3	Village of Upper Alton	do	1896	Drove	80'	4"			
4	Equitable Powder Co	T. 5 N., R. 9 W	1896	Dug	16'	3"		Drinking	10 gallons per minute
5	Union Cap & Chemical Co	do	1900	Drilled	40'	6"	5'	Factory	
6	Big Four Railroad Co	do	1894	do	54'	8"	30'	Locomotives	125 gal. per min. for 10 hrs
7	Big Four Railroad Co	do	1906	do	do	do	do	do	do
8	A. E. Benbow	do	1896	do	80'	2"		Domestic	
9	Hunter Bros	T. 4 N., R. 8 W	1905	do	365'		Little watr	Mill	
10	H. M. Groves	do		Dug	25'	3'		Domestic	
12-16	Edwardsville Water Co	do	1899	Drilled	60'	6"		City	25,000 gal. per hour
17a	Ringring Ernst	T. 4 N., R. 9 W	1894	Drove	35'	4½"	25'	Domestic	
17b	C. W. Smith	do	1905	do	do	do		do	
18	Big Four Railroad	do	1905	do	56'	3"		Locomotives	
19	John Voigt	do	1884	Dug	28'	4'	26'	Domestic	
20	F. Martin	do	1879	do	do	do	do	do	
21	Harry Simon	T. 3 N., R. 8 W	1886	do	40'	3½	10'	do	
28	Ferdinand & Kellar	do		Drilled	1,400'				
31-34	Collinsville Water Co	do	1901	Driven	90'	10"	75-80	City	300,000 gal. per day, 2 wells
35	Bob Stewart	T. 2 N., R. 9 W		Dug	25'	4½'		Domestic	
36	Henry Seebode	T. 3 N., R. 9 W		do	30'	2'	16'	do	
37									
38									
39	Vandalia Railroad	T. 2 N., R. 9 W	1903	Drove	95'	6"	30-40	Railroad shops	200,000 gallons per day
41	Corn Products Refining Co	T. 3 N., R. 10 W	1903	Drilled	80'	10"	10'	Manufacturing	3,000,000 gallons daily
42	American Steel Foundries Co	do	1899	Bored	80'	6"	—25'	do	50,000 gal. in 10 hours
43	"My" Laundry	do	1902	Driven	35'	1½"	—15'	Laundry	
44	Hoyt Metal Co	do	1905	Drilled	250'	10"	—20'	Cooling in manufacturing	500 gallons an hour
45	Neidringhaus Steel Mills Co	T. 3 N., R. 9 W	1903	do	2,590'	10"	+40	do	
46	American Car and Foundry Co	T. 3 N., R. 10 W	1900	Driven	65'	6"		Boiler	
47	Heimbacher Forge & Roll'g. Mills Co	do	1905	do	60'	10"	—14'	Cooling	Pump 250,000 gal. daily
48	Tri-City Ice and Refrigerating Co	do	1902	do	100'	6"	—20'	do	Pump 12,000 gal. daily
50	Interstate Cooperage Co	do	1881	do	35'	1½"	—12'	Drinking	
51	Interstate Cooperage Co	do	1902	do	65'	6"	do	Boiler	
52	Meyer Packing Co	T. 2 N., R. 10 W	1903	Drilled	87'	6"		Condensing	
53	Empire Carbon Works	do	1901	do	80'	6"		do	
54	Empire Carbon Works	do	1001	do	100'	8"		do	
55a-g	Armour Packing Co	T. 2 N., R. 9 W	1903	do	do	6"		do	

Location and Character of Wells—Continued.

Number.	Owner.	Location.	Year.	Class.	Depth.	Diameter.	Head.	Use.	Yield.
56a-c	Swift & Co	T. 2 N., R. 10 W	....	Drilled	85′	6″		Scrubbing	
57	East Side Packing Co	T. 2 N., R. 9 W	1906	do	100′	8″		Condensing	
58	East Side Packing Co	do	1906	do	do	do		do	
59	Hammer Bros. Lead Works	do	1901	do	85′	4″		Plant	
60	Railway Steel Spring Co	do	1903	Drove	80′			Boilers, hydraulic mach'y	
61	Carbonic Dioxide Co	T. 2 N., R. 10 W	1905	do	79′	8″	75-76	Cooling	50 gal. per min. for 24 hrs.
62	Merchants Ice and Fuel Co	do	1901	do	102′	10″	92′	do	500 gal. per min.
63	Republic Iron Works	do	1896	Drilled	500′	6″	12-15′	Drinking, boilers	
64	Hezel Milling Co	do	1902	Drove	35′	4″		Not in use	
66-67	E. St. Louis & Suburban Railway	T. 2 N., R. 9 W	1903	do	90′	10″		Wetting coal ashes, etc	150,000 gallon per day
68	American Steel and Wire Co	do	1904	do	52′	3″		Cleaning rods	
69	Central Brewing Co	do	1902	Drilled	360′	6″		Cooling	400 gallon per minute
70	American Steel Co	do	1900	do	450′	do		Not in use	
71a-c	Illinois Mineral Milling Co	do	....	Drove	56′	2½″	47′		
71b	Illinois Mineral Milling Co	do	....	do	70′	do	66′		
71c	Illinois Mineral Milling Co	do	....	Dug	14′	4½′	10′		
72a	St. Louis Steam Forge and Iron Wks	do	1900	Drove	40′	2″		Drinking	
72b	St. Louis Steam Forge and Iron Wks	do	1900	do	do	do		do	
72c	St. Louis Steam Forge and Iron Wks	do	1900	do	42′	5″		Cooling	
73	The Pittsburg Reduction Co	do	1903	Drilled	150′	8″	135′	Cooling, condensing	1,100 gal. per minute
74	The Pittsburg Reduction Co	do	1903	do	140′	8″	do	do	3,000 gal. per minute
75	The Pittsburg Reduction Co	do	1905	do	120′	do	105′	do	do
76-79	E. G. Helm	do	1906	Drove	40′	1½″			
80	International Leather Co	T. 2 N., R. 8 W	1906	Drilled	90′	10″		Factory	
81	International Leather Co	do	1906	do	85′	do		do	
82	E. Webb	do	1876	Dug	25′	3½′		Domestic	
83	Joe DeLorme	do	1902	Drove	45′			do	
84	Wm Powell	do	1875	Dug	25′	4′		do	
85	Eliza Strube	do	1875	do	31′	3′		do	
86	Wm. Mowe	do	1876	do	34′	3′		do	
88	J. W. Moser	do	1865	do	26½	3½′		do	
89	Victor Moser	T. 2 N., R. 9 W	1895	do	40′	4½′		do	
90	Jessie Schultz	do	1856	do	35′	5′		do	
91	Victor Moser	do	1905	do	25′	4½′		do	
92a	Edward Francois	do	1900	do	16′	4″		do	
92b	J. L. Boisseau	do	1881	do	25′	3″		do	
93	P. H. Traband	do	....	do	do			Washing	
94	P. H. Traband	do	1897	Drilled	782′	10″		Bottling	
95	American Carbon and Battery Co	do						Factory	
96	E. I. Dupont Co	T. 1 N., R. 9 W	1892	do	400′	5″	350′	do	

97	Superior Coal and Mining Co.	..do.	1905	..do.	585′	4″	350′	Plant	
98	Southern Coal Co.	..do.	1902	..do.	625′	6′		Boilers	
99	Priester's Park	T. 1 N., R. 8 W	1889	..do.	605′	8″		Drinking, bottling	
100	Peter Vœllinger	..do.	1903	Dug	30′	4′		Domestic	
101	Union Place	..do.	1876	..do.	23′	2½′		Stock	
102	St. Clair Vinegar Co.	..do.		Drilled	593′	4″		Factory	
103	St. Clair Vinegar Co.	..do.	1906	..do.	being d'g	6″		..do.	
104	John Burg	T. 1 N., R. 10 W		Dug	18′	4′	—6′	Domestic	
106	Louis Hoiser	..do.		..do.	65′	..do.		..do.	
108	Caspar Stolle Quarry & Construct. Co	..do.		Spring				Boiler	
109	Caspar Stolle Quarry & Construct. Co	..do.	1902	Dug	45′	4′	—6′	Domestic	
110	Iron Mountain Railroad	..do.	1906	..do.	70′	12′		Yards and locomotives	
111	N. Boismenne	..do.	1899	Drove	27′	2″		Domestic	
112	Lewis Daughin	..do.	1898	..do.	33′			..do.	
113	J. N. Carlton	..do.	1899	..do.	27′	2″		..do.	
114	Swartz	..do.			54′	4″		..do.	
115	C. W. Droit	T. 2 N., R. 7 W							
116	Joe A. Kurrus	T. 1 N., R. 10 W	1899	Dug	15′	3′			
117	C. W. Droit	..do.	1902	Drove	26′	1¼″		Domestic	
118	American Bottle Co.	T. 1 N., R. 8 W	1902	Drilled	556′	6″		Factory	
120	Citizens Ice Co.	..do.	1893	..do.	425′	..do.		Plant	
122	St. Clair County Farm and Hospital	..do.	1901	..do.	500′	..do.		Domestic	
124	Austin Badgly	..do.	1905	Dug	36′			..do.	
125	Pittsburg Mining Co.	..do.	1841	..do.	40′			Mine	
126	Austin Badgly	..do.	1902	..do.	36′			Domestic	
127	Summit Coal Mining Co.	..do.	1895	..do.	185′			Shaft	
128	Austin Badgly	..do.	1838	..do.	30′			Domestic	
129a–c	O'Fallon Elec. Lt. and Water Co.	T. 2 N., R. 7 W	1894	Drilled	40′	8″		City	
130	Tiedeman Milling Co.	..do.	1875	Dug	..do.	4″		Plant	
131	Collinsville Water Co.	T. 3 N., R. 8 W	1895	Drilled	571′	6″		Not in use	
132	Collinsville Water Co.	..do.	1889	..do.	602′	6–12″		..do.	
133	Southern Coal Co.	T. 1 N., R. 7 W							
134	Julius Knobelock	..do.	1876	Dug	32′	4′		Stock	
135	J. L. Hare	T. 1 N., R. 8 W	1856	..do.	40′	3′		Domestic	
136	Augustus Chenot	..do.	1846	..do.	32′	4′		..do.	
137	J. P. Goundlach	..do.	1853	..do.	30′	..do.		..do.	
138	V. G. Johnson	..do.	1846	..do.	30′	..do.		..do.	
139a	Star Brewery	..do.	1886	Drilled	700′	6″		Not in use	
139b	Star Brewery	..do.	1894	..do.	..do.	..do.		..do.	
139c	Star Brewery	..do.	1898	..do.	..do.	..do.		..do.	
140	Natural Gas Co.	..do.							
141	Western Nail Works	..do.							
143	Harrison Switzer Milling Co.	..do.	1890	..do.	400′	4″		Mill	
144–151	Belleville Deep Well Water Co.	..do.	1886 1905	..do.	..do.	8⅝′		City	
152	Belleville Stove and Range Work	..do.	1886	..do.	410′	6″		Factory	
153 to 170	Belleville Deep Well Water Co.	..do.	1886 1905	..do.	400′	7⅝″		City	
171	Louis Kasina	T. 1 N., R. 10 W		Dug	35′	4′	—10′	Domestic	
173	Western Brewery Co.	T. 1 N., R. 8 W	1896	Drilled	485′	6″		Brewery	
175	Austin Badgley	..do.			35′			Domestic	

Location and Character of Wells—Concluded.

Number.	Owner.	Location.	Year.	Class.	Depth.	Diameter.	Head.	Use.	Yield.
176	George Haig	T. 2 N., R. 8 W	1898	Dug	40'	3'		Domsetic	
177	T. T. Ramey	T. 3 N., R. 9 W	1895	Bored	do.	do.		do.	
178	Donk Brcs. Coal and Coke Co	T. 3 N., R. 8 W	1901	Dug, drld	120'				
179a	Morris Packing Co.	T. 2 N., R.10 W	1896	Driven	75'	8"		Cleaning, condensing	100 gallons per minute
179b	Morris Packing Co.	do.	1896	do.	do.	do.		do.	do.
179c	Morris Packing Co.	do.	1898	do.	do.	do.		do.	do.
179d	Morris Packing Co.	do.	1898	do.	do.	do.		do.	do.
179e	Morris Packing Co.	do.	1902	do.	do.	do.		do.	do.
179f	Morris Packing Co.	do.	1904	do.	do.	do.		do.	do.
179g	Morris Packing Co.	do.	1906	do.	100'	10"			
180	St. Louis Compress Co	do.	1901	do.	65'	do.		Plant	200,000 gallons per day
181	John Harold	T. 1 N., R. 8 W	1898	Dug	20'	5'		Domestic	
182	John Schmitt	T. 3 N., R. 9 W	1856	do.	28'	4'		do.	
183*	Frank Butterwick		1879	do.	32'	3'		do.	
184	Millstadt Electric Light Plant		1896	Drilled	623'	8"		Town	
185	City Well of Millstadt		1895	do.	614'	8–6"		do.	
186	The Millstadt Brewery Co		1902	do.	300'	6"		Brewery	
187*	The Millstadt Brewery Co		1902	do.	280'	4"		do.	
188	Equitable Powder Mfg. Co.	T. 5 N., R. 9 W	1904	do.	900'+	6"		Not in use, salt water	
189a	Beal Bros.	do.	1904	do.	37'	1½"		Factory	
189b	Beal Bros.	do.	1905	do.	40'	2"		do.	
189c	Beal Bros	do.	1906	do.	35'	4"		do.	
190	W. A. Clark	do.	1900	do.	22'	2"		Domestic	
191†	John Dahmer			Dug	45'	6'		do.	
192	Henry Miller		1876	do.	40'	4'		do.	
193	P. H. Postel Milling Co.	Mascoutah	1895	Drilled	3,069'	3"		Not in use, salt water	
195	Mascoutah Brewing Co.		1899	Dug	35'	12'		Brewing.	
196	Nicholas Staub		1866	do.	40'	5'		Domestic	
197	J. H. Richardson			do.	30'			do.	
198	Julius Postel	Mascoutah	1904	Bored	52'	4"		do.	
199	Freeburg Water Co		1897	Lake	4 acres			Town	
200	H. L. Easley	Freeburg	1894	Dug	70'	6'		Creamery	
201	John Koesterer		1876	do.	21'	3'		Domestic	
207	E. G. Helm	T. 2 N., R. 9 W	1906	Driven	40'	1½"			
208	Joe A. Kurrus	T. 1 N., R.10 W		Drilled	103'	2¼"		Domestic	

* Beyond the southern margin of the East St. Louis District. †191–201 Beyond the southeastern margin of the East St. Louis district, 191–201.

Notes on Individual Wells.

1A—HARRY L. MEYER, NORTH ALTON, ILL.

Section.	Feet.	
	Thickness.	Depth.
Yellow clay	25	25
Sand and gravel (dry)	5	30
Blue clay, hard	20	50
Sand (water)	5	55

2A—LUER BROS., ALTON, ILL.

Reaches limestone. The water is used for cooling purposes.

2B—ALTON PACKING CO., ALTON, ILL.

A flowing well; the water, however, is bad since it has a large quantity of mineral salts, and is used for condensing purposes only. Analysis No. 14,649.

4—EQUITABLE POWDER CO., EAST ALTON, ILL.

This well is lined with a 36-inch sewer piper. The water is used for drinking purposes.

6, 7—BIG FOUR RAILROAD, EAST ALTON, ILL.

Section.	Feet.	
	Thickness.	Depth.
Sand	30	30
Quicksand	12	42
Sand	12	54
Blue clay (fire)	.25+	54.25+

9—HUNTER BROS., EDWARDSVILLE, ILL.

This well was not finished when visited by the writer. Although the well had been sunk to 365 feet, water came into it only at the 25-foot level. In this respect it is similar to the shallow wells in the neighborhood. No log of the well was kept. Analysis No. 14,657.

18—BIG FOUR RAILROAD, MITCHELL, ILL.

Section consists of alluvial deposits, "blue sandy dirt," mixed with sand at various depths. Water found in abundance at 25 feet and in coarse blue sand 56 feet below the surface.

31—COLLINSVILLE WATER CO., COLLINSVILLE, ILL.

This number covers four wells which are located at the foot of the bluff, beside the East St. Louis and Suburban Electric Railroad, via Monks Mound. They are arranged in the form of a square, 200 yards apart. (See plate 4.) Before the water is used in the boiler at the pumping station it is run through a heater that takes out a large part of the matter which would otherwise collect as a red scale on the side of the boilers.

36—HENRY SEEBODE, NEAR MONK'S MOUND.

This well is situated on a low mound.

37—NEAR MONK'S MOUND.

Section taken from the field notes of N. M. Fenneman. Samples kept by S. L. Schellenberger, 1121 St. Clair avenue, East St. Louis. The well is located a quarter of a mile southwest of well 165, Monk's Mound, in St. Clair county. All samples marked C. D. Co. O. G. Wilson was the driller.

Section.	Feet. Thickness.	Feet. Depth.
Dirt	40	40
Gray sand	20	60
Very course sand, grains of various rock as if glacial material	10	70
Coarse sand and gravel pebbles of brown and yellow quartzite, greenstone, etc., shells, fragments	80	150
Black clay, almost non-calcareous	55	205
Limestone fragments, may be mixed shale and clay	5	210
Gray, non-calcareous shale	5	215
Light black, clay or shale, non-calcareous	5	220
Same laminated, gray and white	5	225
Gray limestone churned to a very fine sand	5	230
Gray, very siliceous limestone, possibly chert, but looks like sand grains; comes in large fragments	5	235
Very fine white to gray sandstone, almost non-calcareous	65	300
Light colored limestone, churned to very fine sand	5	305
Light sandstone, very fine	10	315
Dense white limestone	45	360
Darker limestone	20	380
Light limestone, dense	30	410
Very ferruginous limestone	10	420
Very ferruginous limestone, cherty	20	440
Dense gray limestone	20	460
Dense gray limestone	30	490
Lighter limestone	15	505
Gray limestone	10	515
Darker limestone	10	525
Limestone and chert, very ferruginous	10	535
Limestone less ferruginous	15	550
Limestone less ferruginous	10	560
Limestone less ferruginous	10	570
Limestone less ferruginous	10	580
Limestone less ferruginous, finely powdered	10	590
Limestone less ferruginous, some chert	35	625
Limestone, largely chert, crinoid stems	25	650
Dark gray limestone	20	670
Mostly white chert	10	680
Light colored limestone, often stuck together with light colored clay which may have been largely washed out	38	718
Blue calcareous clay	62	780
Gray cherty limestone	10	790
Nearly all white chert, finely powdered but angular	10	800
Limestone and white chert	10	810
Largely white chert, finely powdered but angular	30	840
Largely white chert, finely powdered but angular	10	850
Largely white chert, as fine as glass sand	20	870
Limestone and white chert	10	880
Largely white chert fragments	15	895
White limestone and white chert	55	950
Largely white chert fragments	15	965
Greenish gray limestone	30	995
Greenish gray limestone, much chert of similar color	20	1,015
Pink calcareous clay	15	1,030
Pink calcareous clay	15	1,045
Limestone white to green and red, crinoid stems	5	1,050
Light green calcareous plastic clay	2	1,052
Light colored dense limestone	18	1,070
Light colored dense limestone, finely churned	5	1,075
Mainly limestone but has Fern Glen fragments, grains	3	1,078
Finely powdered pink limestone like Fern Glen, large silica grains, round	3	1,081
Finely powered but more gray limestone fragments	14	1,095
Dark blue clay, slightly calcareous	10	1,105
Blue shale fragments, calcareous	20	1,125
Blue shale fragments, more gritty, non-calcareous	10	1,135
Gray limestone chips	35	1,170
Gray to brownish pink gritty limestone, fragments are almost all pink	25	1,195
Greenish gray limestone fragments	10	1,205

Monk's Mound Well—Concluded.

Section.	Feet. Thickness.	Feet. Depth.
Gray and pink gritty	5	1,210
Gray and pink gritty	3	1,213
Gray and pink gritty, but churned to very fine sand	12	1,225
Gray limestone chips	5	1,230
Gray limestone chips, pink fragments still intermixed	20	1,250
Gray limestone chips, mostly pinkish	5	1,255
Light gray limestone, in sharp chips	5	1,260
Light gray limestone	5	1,265
Light gray limestone, finer sand more rounded	5	1,270
Light gray limestone	5	1,275
Light gray limestone,pyrite noted	5	1,280
Light gray limestone, except pyrite	5	1,285
White limestone ground to coarse sand	10	1,255
White limestone ground to coarse sand	5	1,300
White limestone fragments	10	1,315
White limestone in rounded grains, some gray and appear very siliceous	10	1,325
White limestone, but none of the gray siliceous grains	10	1,335
Greenish gray shale, almost non-calcareous	20	1,355
Greenish gray shale, almost non-calcareous	25	1,380
Dark gray or greenish gray limestone, soft enough to be a calcareous shale	110	1,490
Pinkish white, probably siliceous limestone	120	1,510
Probably siliceous limestone, milk-white	10	1,520
Probably siliceous limestone, milk-white	10	1,530
Probably siliceous limestone, milk-white	10	1,540
Probably siliceous limestone, milk-white	40	1,580
Siliceous chips, large admixture of dark gray slaty grains, non-calcareous	20	1,600
Siliceous chips, large admixture of dark gray slaty grains, non-calcareous	50	1,650
Siliceous chips, the gray disappearing	20	1,680
Gray limestone	20	1,700
Lighter, yellow limestone	30	1,730
Lighter, yellow limestone	25	1,755
Lighter, yellow limestone	20	1,775
Brown gray limestone, churned to fine sand	5	1,780
Brown gray limestone, churned to fine sand	35	1,815
Brown gray limestone, churned to fine sand	160	1,975
Siliceous sand, round grains, plainly St. Peters	100	2,075
Siliceous sand, round grains, plainly St. Peters	75	2,100

38—NEAR MONK'S MOUND. (SEE NOTE NO. 37.)

Located in Madison county, Illinois, just across the county line, perhaps 2,000 feet northwest of 37. It is also on top of a mound probably 12 feet high.

39—VANDALIA RAILROAD SHOPS, EAST ST. LOUIS.

Lime and soda ash is used to soften the water and to throw down a soft scale which may be discarded easily.

41—CORN PRODUCTS REFINING CO., GRANITE CITY.

This number covers a series of seven wells from 70 to 90 feet deep and arranged in an east-west line on the property of the Corn Products Company. Water is obtained from clean well-rounded gravel. The quality of the water is not first-class and the supply is limited. As located at present, the wells interfere with each other. The water table is depressed to the point where the pumps begin to pound if driven to their full capacity. New wells are to be sunk and the distance between wells increased to 225 feet. The 20-foot Cook well strainer is used in all the wells. A slow movement of sand through the gravel clogs the screen so that back flushing is resorted to at a pressure of 180 to 200 pounds. This relieves the wells for a week or so. The original size of the screen opens were No. 8, but these clogged so quickly they were redrawn and enlarged. The enlargement resulted in the collection of sand in the bottom of the well. The bucketing out of this seems more effective

than the almost continual back-flushing demanded by the smaller meshed screens. The degree of interference may be determined from the fact that 1,000,000 gallons may be pumped from one well in 24 mours, while from the seven but 3,500,000 or 4,000,000 gallons may be pumped in the same time.

42—AMERICAN STEEL FOUNDRIES CO., GRANITE CITY.

Surface of ground at well 38 feet above low water mark. A 20-foot Cook strainer is employed. If the water is allowed to stand a few hours a large amount of iron is precipitated. The company buys 4,500,000 gallons of water from the city per month.

Section.	Feet.	
	Thickness.	Depth.
"River bed"	10	10
Quicksand	60	70
Gravel	10	80

43—"MY" LAUNDRY, GRANITE CITY.

Water from this well is used in a laundry which uses in addition 800 gallons of city water daily. The city water costs the laundry $0.30 per 1,000 gallons. The screen originally put down was rusted through in three years. Well located in Madison on C street between 18th and 19th avenues.

44—HOYT METAL CO., GRANITE CITY.

Water from this well cannot be used in boilers as it scales badly. The company uses 2,000,000 to 3,000,000 gallons of city water per month. Water is obtained from limestone from a depth of 150 to 250 feet, with 100 feet of bleeding surface. Both the 80-foot water in the gravel and the 150 and 250-foot water could be used if a screen were inserted at 80 feet. This is not done at present because of the fear that sand may enter and clog rock. Sand would undoubtedly enter, but could be bucketed out frequently.

45—NIEDRINGHAUS STEEL MILLS CO., GRANITE CITY.

Water is salty and used only for cooling purposes in the stamp mills.

46—AMERICAN CAR AND FOUNDRY CO., MADISON.

This number covers three wells from 64 to 68 feet deep. Sand occurs above the gravel from which water is drawn. Sixteen-foot Cook strainers are used. Three wells yield 500 gallons per minute. Wells are 6 inches in diameter. A 4-inch well previously used clogged with sand, was dynamited, with no success, the screen being torn to pieces and sand filling the bottom. It should be noted that dynamiting is only successful in rock and where casing is not employed. To dynamite inside the casing and in gravel or sand is worse than useless. The water is pumped into ponds for aeration and precipitating the iron and to allow sand to settle. It would be more beneficial to put gravel in bottom of pond and aerate with risers.

47—HELMBACHER FORGE AND ROLLING MILLS CO., MADISON.

Use 100,000 to 150,000 gallons monthly of city water for drinking purposes. The water is pumped into ponds for aeration and precipitation of iron as above. The well is supplied with a 16-foot screen.

Section.	Feet.	
	Thickness.	Depth.
Sand	50	50
Gravel	4	54
Coarse sand	5—	60—

48—TRI-CITY ICE AND REFRIGERATING CO., MADISON.

Well yields water so chalybeate that it cannot be used. Scales refrigerating pipes so rapidly as to clog them in a short time. Use 6,000 gallons of city water daily for ice. City water incrusts pipes, but not so rapidly as well water.

53, 54—EMPIRE CARBON WORKS, EAST ST. LOUIS.

Section.	Feet.	
	Thickness.	Depth.
Gumbo	1	1
Loam	70	71
Coarse sand and gravel	29+	100

55—ARMOUR PACKING CO., EAST ST. LOUIS.

The water from these wells is used only for condensing and cleaning. The water is raised by means of cold air and spilled out on a platform located between the power-house and the lard and cooperage buildings. By spilling the water on this platform it is aerated to such an extent that a large portion of the iron contained in the water runs down to the ground into a granitoid reservoir. From this reservoir the water is pumped up through a large pipe to the condensing stacks on the top of the power-house. The water is then delivered to the large reservoir, from which it is distributed through pipes to all parts of the plant for cleaning purposes. A yellow scale is deposited on the platform, inside and outside of the pipes, and on the sides of all the reservoirs through which it passes.

The larger portion of the water used at the plant comes directly through a 12-inch main from the city pumping station.

56—SWIFT & CO., EAST ST. LOUIS.

Ten wells have been put down, but only three are used. The water obtained comes from the gravel, 85 feet below the surface. The ground water level varies from 10 to 30 feet. The water is used for cleansing purposes.

57, 58—EAST SIDE PACKING CO., EAST ST. LOUIS.

The water from these wells is used for condensing purposes.

Section.	Feet.	
	Thickness.	Depth.
Gumbo	6	6
Sand	16	22
Quicksand	10	32
Coarse sand	20	52
Loam	28	80
Coarse gravel	20	100

Location and Character of Wells—Continued.

Number.	Owner.	Location.	Year.	Class.	Depth.	Diameter.	Head.	Use.	Yield.
56a-c	Swift & Co	T. 2 N., R.10 W		Drilled	85′	6″		Scrubbing	
57	East Side Packing Co	T. 2 N., R. 9 W	1906	do	100′	8″		Condensing	
58	East Side Packing Co	do	1906	do	do	do		do	
59	Hammer Bros. Lead Works	do	1901	do	85′	4″		Plant	
60	Railway Steel Spring Co	do	1903	Drove	80′			Boilers, hydraulic mach'y	
61	Carbonic Dioxide Co	T. 2 N., R.10 W	1905	do	79′	8″	75-76	Cooling	50 gal. per min. for 24 hrs.
62	Merchants Ice and Fuel Co	do	1901	do	102′	10″	92′	do	500 gal. per min.
63	Republic Iron Works	do	1896	Drilled	500′	6″	12-15′	Drinking, boilers	
64	Hezel Milling Co	do	1902	Drove	35′	4″		Not in use	
66-67	E. St. Louis & Suburban Railway	T. 2 N., R. 9 W	1903	do	90′	10″		Wetting coal ashes, etc	150,000 gallon per day
68	American Steel and Wire Co	do	1904	do	52′	3″		Cleaning rods	
69	Central Brewing Co	do	1902	Drilled	360′	6″		Cooling	400 gallon per minute
70	American Steel Co	do	1900	do	450′	do		Not in use	
71a-c	Illinois Mineral Milling Co	do		Drove	56′	2¼″	47′		
71b	Illinois Mineral Milling Co	do		do	70′	do	66′		
71c	Illinois Mineral Milling Co	do		Dug	14′	4½′	10′		
72a	St. Louis Steam Forge and Iron Wks	do	1900	Drove	40′	2″		Drinking	
72b	St. Louis Steam Forge and Iron Wks	do	1900	do	do	do		do	
72c	St. Louis Steam Forge and Iron Wks	do	1900	do	42′	5″		Cooling	
73	The Pittsburg Reduction Co	do	1903	Drilled	150′	8″	135′	Cooling, condensing	1,100 gal. per minute
74	The Pittsburg Reduction Co	do	1903	do	140′	8″	do	do	3,000 gal. per minute
75	The Pittsburg Reduction Co	do	1905	do	120′	do	105′	do	do
76-79	E. G. Helm	do	1906	Drove	40′	1½″			
80	International Leather Co	T. 2 N, R. 8 W	1906	Drilled	90′	10″		Factory	
81	International Leather Co	do	1906	do	85′	do		do	
82	E. Webb	do	1876	Dug	25′	3½′		Domestic	
83	Joe DeLorme	do	1902	Drove	45′			do	
84	Wm Powell	do	1875	Dug	25′	4′		do	
85	Eliza Strube	do	1875	do	31′	3′		do	
86	Wm. Mowe	do	1876	do	34′	3′		do	
88	J. W. Moser	do	1865	do	26½	3½′		do	
89	Victor Moser	T. 2 N., R. 9 W	1895	do	40′	4½′		do	
90	Jessie Schultz	do	1856	do	35′	5′		do	
91	Victor Moser	do	1905	do	25′	4½′		do	
92a	Edward Francois	do	1900	do	16′	4″		do	
92b	J. L. Boisseau	do	1881	do	25′	3″		do	
93	P. H. Traband	do		do	do			Washing	
94	P. H. Traband	do	1897	Drilled	782′	10″		Bottling	
95	American Carbon and Battery Co	do						Factory	
96	E. I. Dupont Co	T. 1 N., R. 9 W	1892	do	400′	5″	350′	do	

70—AMERICAN STEEL CO., EAST ST. LOUIS.

Water not used. Scale in the boilers is an objectionable feature. Analysis No. 14,620.

71—ILLINOIS MINERAL MILLING CO., EAST ST. LOUIS.

The water is used for boiler purposes. It forms a scale, but not in excess of the city water. Analysis No. 14,622.

72—ST. LOUIS STEAM FORGE & IRON WORKS, EAST ST. LOUIS.

Used for cooling purposes. It is also used as a drinking water, but is seriously objected to by the workmen.

73-75—THE PITTSBURG REDUCTION CO., EAST ST. LOUIS.

In 1905 well 73, which was sunk in 1903, had decreased in capacity from 1,100 to 300 gallons per minutes. The amount needed for the plant is 1,100 gallons per minute for 12 hours, or 792,000 gallons a day. Since the well did not yield this amount a new well was sunk, No. 75. All of the casing from the 1903 well was drawn except the lower part, which broke away. It is supposed that iron carbonate coated the screen and clogged the holes of it to such an extent that the capacity was decreased as mentioned above.

The new well was finished and strainers put into it December, 1905. Bottom of strainer 128 feet below 100-foot elevation and is 21.5 feet long over all. It was made by the Cook Well Company of St. Louis, Mo. It is a No. 20 strainer. 1.5 feet lapping inside of boring. The strainer is surrounded by a coarse sand and gravel 20 feet thick. The well was sunk 7 feet lower into a blue shale, but it was thought best to pull the pipe above this and to leave the strainer in the coarse sand and gravel.

This company has devised a filtering process which purifies the well water before it is used in the boilers of the plant. The city water is used only for drinking purposes. Analyses No. 14,621 and 16,624.

88—J. W. MOSER, CASEYVILLE, ILL.

This well had as good water as any other well in the village until the spring of 1906, when with the heavy rains the water suddenly turned salty after the well had been pumped dry. The well was pumped dry at various times in less than one hour with a 2-inch double action pump, one-half gallon each stroke. The well holds 25 barrels and 30 gallons with the ground water level 10 feet from the top. The morning following the day when the well was pumped dry the water returned to its former level. Analysis No. 14,626.

89—VICTOR MOSER, FRENCH VILLAGE, ILL.

Blue clay, 40 feet; no sand.

90—JESSIE SCHULTZ, FRENCH VILLAGE.

This well is located beside the county road at French Village. It is used for drinking, stock and other purposes. The well is very old.

Section.	Feet.	
	Thickness.	Depth.
Loess	15	15
Gravel	.25	15.25
Blue shale	2	17.25
White sand	18+	35.25+

92a—EDWARD FRANCOIS, FRENCH VILLAGE, ILL.

Pumping two full hours through a 1¼-inch pipe will empty this well.

Section.	Feet.	
	Thickness.	Depth.
Loess	5	5
Blue clay	2	7
Sand	9+	16+

Oftentimes Schoenberger creek overflows and the flood water flows into the wells and cellars in the vicinity of the well. When the creek is normal water often stands 2 feet, 3 inches deep in the cellars which are approximately 4 feet, 5 inches deep. Not only is this true of cellars in the valley of the creek, but in the hill side as well.

92—J. L. BOISSEAU, FRENCH VILLAGE, ILL..

This well is located 90 yards from the bank of Schoenberger creek. At flood times water flows into the top of the well.

94—P. H. TRAHAND, EDGEMONT, ILL.

This well is located at the foot of the bluffs at Edgemont, 440 feet above tide. The well is lined with a 12-inch casing projecting 6 feet above the surface. If the casing were not so high the well would flow; instead, water is pumped out of it to supply a large bottling trade.

97—SUPERIOR COAL & MINING CO., BELLEVILLE, ILL.

Salt water was encountered approximately 450 feet below the surface. It was cased off and the well put down to its present depth, 585 feet.

99—PRIESTER'S PARK, BELLEVILLE, ILL.

Well supplies water to the St. Clair County Club and to the park. It is bottled and sold on the market. Pumps with 4-inch working barrel, estimated production 25,000 gallons per day.

100—PETER VOELLINGER, BELLEVILLE, ILL.

Section.	Feet.	
	Thickness.	Depth.
Soil	10	10
Gravel	4	14
Shale, blue	16+	30

Water comes into the well through gravel.

102, 103—ST. CLAIR VINEGAR CO., BELLEVILLE, ILL.

Former head of water 493 feet; present head 393 feet. Water does not scale boilers.

109—CASPAR STOLLE QUARRY & CONSTRUCTION CO., STOLLE, ILL.

The water in this well is from gravel below 42 feet of fine sand. Like the water in the springs in the limestone bluff nearby the water in this well becomes oily after a rain.

113—J. N. CARLETON, EAST CARONDELET, ILL.

Section.	Feet.	
	Thickness.	Depth.
Sand and loam	10	10
Gumbo	2	12
Quicksand	10	22
Gravel (water)	5+	27+

116—JOE A. KURBUS, CAHOKIA, ILL.

This well was put down by the Mississippi Valley Trust Co.

118—AMERICAN BOTTLING CO., BELLEVILLE, ILL.

When water stands for a while has bitter alkaline taste. Does not affect the iron of boilers, but corrodes the brass fittings.

129—O'FALLON ELECTRIC LIGHT & WATER CO., O'FALLON, ILL.

Section.	Feet.	
	Thickness.	Depth.
Brown loam	37	37
Black clay, hard, tough	2	39
Quicksand	1+	40+

Each well has 8-foot strainer. Analysis No. 14,627.

139—STAR BREWERY, BELLEVILLE, ILL.

The three wells of the Star Brewery were abandoned because they furnished an insufficient supply. Water could be had for one and a half hours' pumping only after letting wells rest for three days. The casing was pulled out of two wells and the third one plugged in 1904. At present impounded water from ponds one-half mile north of the plant is used.

140—NATURAL GAS CO., BELLEVILLE, ILL.

Section.	Feet.	
	Thickness.	Depth.
Soil and clay	26	26
Sand and gravel	2	28
Clay	34	62
Hard limestone	43	105
Close grained limestone	15	120
Coal	7	127
Fire clay	2	129
Shale and soft sandstone	169	298
Sandstone	14	302
Black shale	3	315
White sand	10	325
Soft shale	8	333
Sandstone	47	380
White sand	10	390
Gray sand and shale	12	402
White shale	12	414
Red shale	13	427
Soft sandstone	14	441
Hard sandstone	15	456
Gray sandstone	58	514
Limestone	986	1,500

At 298 feet there was considerable water but no casing was needed to shut it out. At 325 feet there was an abundance of water. Fresh water to 514-foot level. Salt water was encountered in the massive limestone.

143—HARRISON SWITZER MILLING CO., BELLEVILLE, ILL.

Section.	Feet.	
	Thickness.	Depth.
Soil	8	8
Limestone	4	12
Clay	46	58
Limestone	38	96
Coal	6	102
Fire clay	2	109
"Hard rock," limestone and shale	142	246
"Rock" limestone	40	286
"Soapstone," shale	32	318
Shale	6	324
Sand (water)	15	340
White sand	66	406

145—BELLEVILLE DEEP WELL WATER CO., BELLEVILLE, ILL.

Well equipped with 4-inch working barrel nd has an estimated capacity of 30,000 gallons a day.

149—BELLEVILLE DEEP WELL WATER CO., BELLEVILLE, ILL.

Well not being operated but equipped with pump, pipe, cylinder and rods; capacity estimated at 12,000 gallons a day. Value of well supposed to have been impaired by sinking a 6-inch casing below sand rock; said casing became fast in well; part of it drilled out.

Section.	Feet.	
	Thickness.	Depth.
Clay	25	25
Gravel	3	28
Limestone	14	42
Shale	125	167
White sandstone	38	205
Shale	100	305
White sandstone	7	312
Shale	25	337
Sandstone	68	405
Gray shale	6	411
Sandstone	230	641

150—BELLEVILLE DEEP WELL WATER CO., BELLEVILLE, ILL.

Well abandoned because of the small amount of water delivered—9,000 gallons a day.

Section.	Feet.	
	Thickness.	Depth.
Clay	34	34
Limestone	10	44
Coal	7	51
Shale and limestone	18	69
Sandstone	7	76
Shale	59	135
Limestone	25	160
Sandstone	34	194
Shale	195	389
Sandstone	23	412
Limestone and shale	20	432

151—BELLEVILLE DEEP WELL WATER CO., BELLEVILLE, ILL.

Section.	Feet.	
	Thickness	Depth.
Soil and drift	30	30
Limestone	15	45
Shale	5	50
Limestone	15	65
Coal	5	70
Shale	30	100
Limestone	50	150
Sandstone	10	160
Gray shale	40	200
Limestone	40	240
Shale	60	300
Limestone	10	310
Red shale	19	329
Sandstone	71	400
Hard limestone	27	427
Gray shale	5	432
Limestone	23	455

Equipped with Gould head; capacity, 27,000 gallons a day.

153—BELLEVILLE DEEP WELL WATER CO., BELLEVILLE, ILL.

Nine and five-eighths-inch casing; 6-inch water pipe; equipped with deep well pump; Gould head; estimated production, 65,000 gallons a day; 50,000 gallons capacity electric pumps; trouble with sand; after cleaning expect production to be 75,000 gallons a day.

154—BELLEVILLE DEEP WELL WATER CO., BELLEVILLE, ILL.

Equipped with Dowie head; 35,000 gallons a day.

155—BELLEVILLE DEEP WELL WATER CO., BELLEVILLE, ILL.

Well abandoned and casing removed on account of insufficient water; capacity, four gallons per minutes.

Section.	Feet.	
	Thickness.	Depth.
Clay	34	34
Limestone	10	44
Coal	6	50
Shale	18	68
Limestone	7	75
Sandstone	59	134
Limestone	25	159
Sandstone	34	193
Shale	195	388
Sandstone	23	411
Limestone and shale	158	569

156—BELLEVILLE DEEP WELL WATER CO., BELLEVILLE, ILL.

Well is not in use.

Section.	Feet.	
	Thickness.	Depth.
Clay	9	9
Fine sand	19	28
Clay and shale	105	133
Limestone	46	179
Sandstone	53	232
Shale	134	366
Sandstone	34	400
Limestone	25	425

157—BELLEVILLE DEEP WELL WATER CO., BELLEVILLE, ILL.

This well supposed to have crevice in the rock; has never been successfully operated with air; 7⅝ casing; 5-inch air pipe; 2¾-inch water pipe.

158—BELLEVILLE DEEP WELL WATER CO., BELLEVILLE, ILL.

Seven and five-eighths-inch casing; 5-inch air pipe; 2¾-inch water pipe. Estimated production 22,000 gallons a day; 30,000 gallons capacity electric pumps.

159—BELLEVILLE DEEP WELL WATER CO., BELLEVILLE, ILL.

Well reaches rock. To get rid of the excess of iron the water is passed through a filter before using it.

159—BELLEVILLE DEEP WELL WATER CO., BELLEVILLE, ILL.

Not considered a good well; 7⅝-inch casing; casing removed March, 1900.

160—BELLEVILLE DEEP WELL WATER CO., BELLEVILLE, ILL.

Seven and five-eighths-inch casing; 5-inch air pipe; 2¾-inch water pipe; estimated production, 22,000 gallons a day.

161—BELLEVILLE DEEP WELL WATER CO., BELLEVILLE, ILL.

Seven and five-eighths-inch casing; 5-inch air pipe; 2¾-inch water pipe; estimated production, 30,000 gallons a day.

162—BELLEVILLE DEEP WELL WATER CO., BELLEVILLE, ILL.

Seven and five-eighths-inch casing; 5-inch air pipe; 2¾-inch water pipe; estimated production, 28,000 gallons a day.

163—BELLEVILLE DEEP WELL WATER CO., BELLEVILLE, ILL.

Well abandoned; 7⅝-inch casing. Casing removed in March, 1900.

164—BELLEVILLE DEEP WELL WATER CO., BELLEVILLE, ILL.

Seven and five-eighths-inch casing; 5-inch air pipe; 3-inch water pipe; estimated production, 32,000 gallons a day; depth, 575 feet.

176—GEORGE HAIG, CASEYVILLE, ILL.

Water found in a sand bed 7 feet thick, 38 feet below the surface. This sand disappears a short distance to the east, rock and coal taking its place. Two hundred yards east of the well a bluff appears in which coal and rock are found in place 30 feet below the surface of the flood-plain. Analysis No. 14,629.

178—DONK BROS.' COAL CO., MARYSVILLE, ILL.

This well was put down by the Donk Bros.' Coal & Coke Company, Marysville, Ill., about a quarter of a mile northeast of the mine. Rock was struck at 75 feet. The well was dug this far and then drilled to 120 feet. The water contains sulphur and was unfit for drinking purposes.

179—MORRIS PACKING CO., EAST ST. LOUIS.

Water used for condensing, cleaning and fire purposes.

208—JOE G. KURRUS, EAST ST. LOUIS.

This well is located on 101 North Third street, East St. Louis. The well was put down for laundry purposes. The water appeared to have no bad effect until the clothes were put in the drying house, when they turned yellow on account of the large amount of iron. The water is used at present for stock purposes.

182—JOHN SCHMIDT, NEAR MONK'S MOUND.

Well located on level ground at the foot of Schmidt's mound.

184—MILLSTADT ELECTRIC LIGHT CO., MILLSTADT, ILL.

Section.	Feet.	
	Thickness.	Depth.
Clay	50	50
Coal	6	56
Fire clay	3	59
Limestone	80	139
Shale	....	....
Sandstone	75	230
Limestone, hard, flinty	300	530

The above is an oral statement by Mr. Jacobus. It is not complete, but since no log was kept, it is the best that can be offered.

188—EQUITABLE POWDER CO., EAST ALTON, ILL.

Limestone of varying texture from 80 feet to 900 feet. The water is salty.

191—JOHN DALMER, MASCOUTAH, ILL.

This well is within the sink hole district. When it was first dug no water was found, but after it had been filled with dirt and rock and reopened there was plenty of water. A clogged sink-hole filled with water stands 100 feet to the south.

192—HENRY MILLER, MASCOUTAH, ILL.

Well in limestone; sunk in a crevice of the rock. Nearby wells unsuccessful.

193—P. H. POSTEL MILLING CO., MASCOUTAH, ILL.

Section.	Feet.	
	Thickness.	Depth.
To first sand	30	30
Quicksand	5	35
White sand	5	40
Gravel at	....	57
Through glacial deposits	....	104
Limestone	8	112
Hard shale	30	142
Limestone	3	145
Coal	6	151
Shale	15	166
Limestone	10	176
Shale	25	201
Coal	5	206
White shale	50	256
Blue shale	40	296
White shale	45	341
Red rock	45	386
Shale	35	421

Postel Milling Co—Concluded.

Section.	Feet.	
	Thickness.	Depth.
Well caved in and had to clean up hole		
Shale	119	540
Limestone	5	545
Sandstone	45	590
Shale	25	615
Limestone	20	635
Well caved in and had to clean up hole		
Red rock	55	690
White shale	20	710
Sandstone	20	730
Limestone	470	1,200
Shale	420	1,620
Shaly limestone	390	2,010
Marl	70	2,080
Limestone	129	2,206
Shale	127	2,333
Limestone	449	2,782
Shale	58	2,840
Limestone	7	2,847
Shaly limestone	51	2,898
Sand and shale	171	3,069

Amount of 12-inch casing used, 108 feet.
Amount of 7⅝-inch casing used, 519.9 feet.
Amount of 5⅝-inch casing used, 91 feet.
Amount of 3-inch casing used, —— feet.

SUMMARY OF CONCLUSIONS.

(By Isaiah Bowman.)

Although a general conclusion accompanies each section of that part of the report relating directly to water supply, a brief and general summary of these conclusions will serve in this place to emphasize the more important results of the present study.

Conclusions Regarding Surface Sources of Water Supply.

(1) In those sections of the district where limestone lies above the surface of the ground water and is extensively dissolved out by percolating waters, the available water is karst water. Its recovery is much more difficult than is the recovery of the ground water below it, which it feeds. In this district underground water occurs in the manner in which ground water is popularly but erroneously supposed to occur—that is to say, in definite underground channels. By reason of the quick descent of rain water to these underground passages karst water is often dangerous for drinking purposes, and the population is driven to the use of rain water conserved in cisterns.

(2) The supply of water from streams is not used to the fullest extent today because of the ease with which ground water may be obtained. The Mississippi river is drawn on for city supply in East St. Louis and a few adjacent towns. The water is extremely roily when first drawn, but by the processes of filtering, aerating, sedimenta-

tion, baffling and by chemical treatment, it is made clean and pure and wholesome. It scales boilers to some extent, but not so much as the ground water, whose use is supersedes. Use can likewise be made of tributaries of the Mississippi.

(3) A number of ox-bow lakes and artificial reservoirs are utilized, but the extent to which this is done is and always will be quite limited. The lakes are roily in spite of some degree of natural sedimentation, and the rank growth of vegetation and the large amount of city wastes dumped into them would lead to deleterious effects were the water used for drinking purposes. The reservoirs are favorable means for securing a puvlic supply, except to the extent to which the watershed is contaminated by wastes. The growth of vegetation on their botoms and shores may easily be prevened by deepening and graveling the bottom and paving the sides.

Conclusions Regarding Underground Sources of Water Supply.

(4) For drinking and other ordinary domestic purposes the ground water of the flood-plain deposits must always constitute the chief source of supply to the flood plain population. By virtue of the fact that fine sands overlie the coarser sand and gravel from which the water is derived, the purity of these waters under ordinary conditions, must always be assured. Not that the fine sands prevent the downward movement of the rain water into the gravels and coarse sands, but that they enforce a movement sufficiently slow to insure pretty thorough filtration. The gravel and coarse sand are not more thoroughly saturated with water than the fiend sand above them, but their water is more available and wells are not regarded as successful which do not reach lenses of coarser material. For boiler purposes the flood-plain water is not desirable in its natural state, being too heavily charged with calcium and magnesium carbonates. The use of compounds is required with it. Several companies are considering the erection of purifying plants which will enable the use of this water, but at present city water is used in the boilers.

(5) The greater part of the upland wil lalways be supplied with water from shallow wells in favorable localities in the loess and drift, the bottom of the well lying a few feet below the level of the water tabe. No special features of water quality or means of acquisition need be summarized here as the problem is wholly one of the simple dug or driven well of the ordinary type.

(6) The deeper waters are all highly mineralized and occur under much greater head than the shallow supplies. They are not valuable except for their medicinal properties, either real or supposed, and can never enter directly into the problem of water supply in a serious way except by possible pollution of sweet surface waters. Occuring with such a great head and with strong mineral substances in solution, they must sooner or later, with the decay of the casings, enter upper horizons to the exclusion of desirable waters. These upper waters are even

at present too hard for boiler use, and will be totally unfit for such use if re-enforced by the water from deep sources. It would be calamitous, indeed, should such a displacement ever occur, and it cannot be too strongly urged that the State adopt measures which will give the upper horizons adequate protection.

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